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(54) **Cam profile summation mechanism**

(57) A rocker system comprising a summation lever and at least one valve actuating lever for use in a valve train of the type having two cams, a summation lever having followers engaging with both cams and a valve actuating lever pivotally connected to the summation le-

ver for opening and closing an engine valve in dependence upon the sum of the lifts of the two cams, characterised in that the summation lever is assembled from opposed face plates and a separately formed hub.

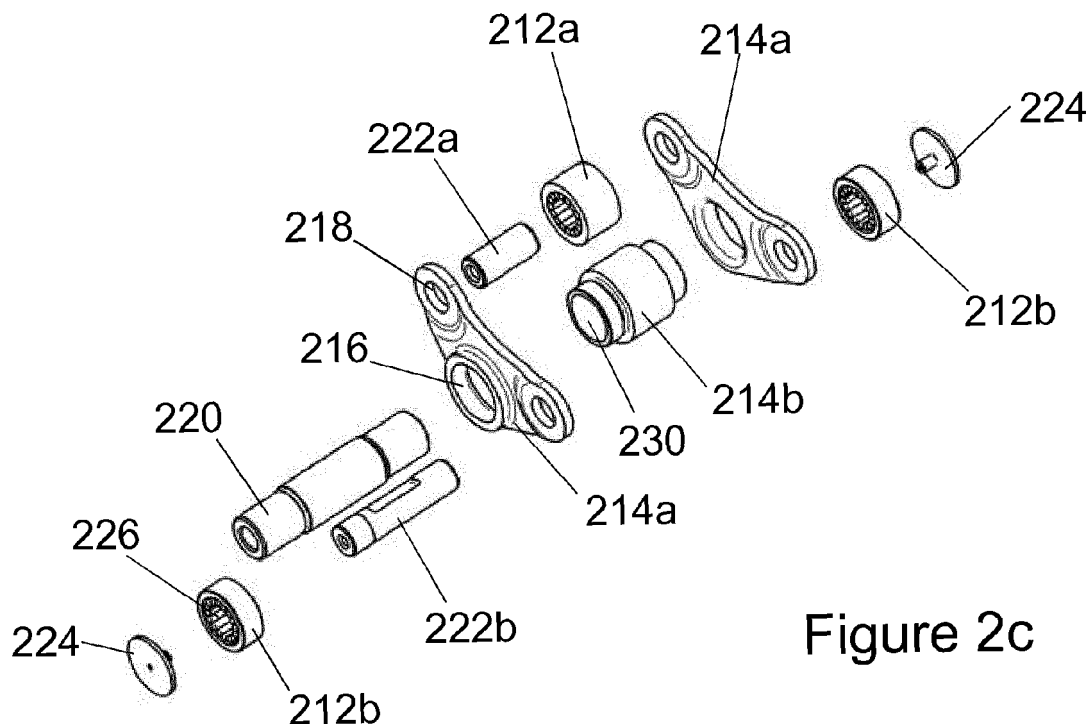


Figure 2c

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Description

Field of the invention

[0001] The present invention relates to variable valve lift and duration systems for internal combustion engines, and more specifically to the manufacture of components within such systems.

Background of the invention

[0002] This invention relates to the variable lift and duration mechanism (VLD) previously developed by the applicants of the present invention. It utilises two concentric camshafts the phase of which may be altered relative to one another. The purpose of these two camshafts is that the lift imparted to the valve is determined by the sum of the lift contributed by each camshaft profile. No lift is imparted to the valve when either camshaft is "off-cam". By varying the phase of the two camshafts, the cumulative lift and duration can be altered. This results in directly altering the opening duration and lift of the engine valve, be it inlet or exhaust.

[0003] The cumulative lift is achieved by the use of a summation lever having cam followers in contact with both sets of cams. If either cam follower is on the base circle of the associated cam, the summation lever merely rocks about a pivot axis connecting it to a valve actuating lever. If both cam followers are in contact with the cam lobes, the summation lever is displaced downwards, and pushes down on the actuating rocker which then pivots about a hydraulic lash adjuster to open the engine valve.

[0004] In common with all variable lift and duration valvetrain systems, the addition of extra components such as the summation lever adds both additional mass and additional cost to the system in comparison to a conventional fixed valvetrain system.

Summary of the invention

[0005] With a view to mitigating the foregoing disadvantages, the present invention provides a variable valve actuating mechanism as set forth in claim 1 of the appended claims.

[0006] Further advantages and embodiments of the present invention are provided in the subsequent appended claims.

Figures 1a, 1b and 1c show a 3D view, a cross section and an exploded view, respectively of a summation lever as shown in the prior art,

Figure 1d shows an exploded view of a summation lever and actuating rocker as shown in the prior art, Figure 1e shows a 3D of the assembled components of figure 1d as shown in the prior art,

Figure 1f shows a 3D of the an assembled rocker system when engaging with a cam shaft and two poppet valves as shown in to the prior art,

Figures 2a, 2b and 2c show a 3D view, a cross section and an exploded view, respectively of a summation lever according to a first embodiment of the present invention,

Figures 3a, 3b and 3c show a 3D view, a cross section and an exploded view, respectively of a summation lever according to a second embodiment of the present invention,

Figures 4a, 4b, 4c and 4d show a 3D view, a cross section, an underneath 3D view and an exploded view, respectively of a summation lever according to a third embodiment of the present invention,

Figures 5a, 5b and 5c show a 3D view, a cross section and an exploded view, respectively of a summation lever according to a fourth embodiment of the present invention,

Figures 6a, 6b and 6c show a 3D view, a cross section and an exploded view, respectively of a summation lever according to a fifth embodiment of the present invention, and

Figures 7a, 7b and 7c show a 3D view, a cross section and an exploded view, respectively of a summation lever according to a sixth embodiment of the present invention.

Detailed description of the drawings

[0007] Starting with the prior art figure 1a, a three fingered summation lever assembly 110 from a known variable lift and duration (VLD) rocker assembly is shown. The lever assembly 110 includes three cam followers or rollers 112a and 112b, one disposed on each finger, for contacting three cam lobes 150. Two of the three lobes having the same cam profile rotate as a pair on one camshaft and the third rotates on the other coaxial camshaft. Both coaxial camshafts rotate together at the same speed, but also may rotate relative to one another altering the phasing and in turn affecting the valve duration and lift.

[0008] The function of the summation lever has already been described above in the introduction.

[0009] A typical VLD summation lever assembly 110 and rocker system as described in GB2378729 are shown in figures 1a to 1f. The main body 114 of the summation lever is made up of a single solid component. Such a component, whilst relatively easy to make in low volume or prototype quantities, is relatively heavy and costly to manufacture in high volume production.

[0010] The main body 114 is cast or machined with a pivot shaft through bore 130 and follower shaft through bores 118. These receive the pivot shaft 120, and follower shafts 122a and 122b respectively. The shafts are typically a form of interference fit within the bores, obtained by heating the summation lever body 114 and then cooling after insertion of the shafts 120, 122a and 122b. The cam followers/rollers 112b are retained on the follower shaft 122b by caps 124. Typically, to reduce friction, roller bearing elements 126 are installed between the follower

and the follower shaft.

[0011] In assemblies of this type, the valve actuating levers 140 are assembled to the summation lever assembly 110, by sliding each of them on to opposite ends of the pivot shaft 120. The pivot shaft acts as a bearing surface within the valve actuating lever allowing the relative rotation of the two levers. The valve actuating levers are prevented from sliding laterally relative to the pivot shaft by virtue of their location on both the engine valve and a hydraulic lash adjuster. There has therefore been no need to provide means for retaining the valve actuating lever to the summation lever assembly.

First Embodiment

[0012] Figures 2a, b and c, show a summation lever assembly 210 according to a first embodiment of the present invention.

[0013] The present invention lies in the construction of the summation lever 210. Where in the prior art, the summation lever was a cast individual component 114, this embodiment is formed from two sheet metal end plates 214a that are press formed, stamped or forged. Holes 216, 218 can be formed at the same time during the stamping process or may be machined to achieve their finished size.

[0014] The plates are held in relation to one another by mutual connection to a hub 214b. The hub 214b is a simple cylindrical shape allowing it to be inexpensively cast or turned. The hub 214b is received at each of its axial ends within holes 216 of each end plate 214a. Typically end plates are heated prior to insertion of the hub 214b in the holes 216. The end plates may then be cooled to form a heat shrunk engagement with the hub. Any alternative method of attachment may be considered such as brazing, welding, gluing, or interference press fitting.

[0015] The interaction between the cam rollers/followers and the cam potentially generates a significant amount of twisting within summation lever. This is more problematic when the summation lever assembly 210 is formed from component pieces. It is therefore beneficial to provide means to prevent the face plates 214a from rotating relative to one another about the hub 214b. This may be achieved by providing a form locking engagement. The intended meaning of form locking is that the engaging mating surfaces are non-circular and therefore not free to rotate relative to one another. This may take the form of a splined engagement between the outer surface on the hub and the inner surface of the holes 216. Any suitable surface keying to prevent rotation of the hub relative to either face plate may be utilised, e.g. castellation, crenulation or a woodruff key. Preventing rotation is more important when the hub 214b is attached to the face plates 214a by means of a press or interference fit.

[0016] Alternatively, since either or both the components may be made from a soft metal, it is possible to provide the surface texturing described above (splines

etc.) on only one component, and to rely on the interference fit between the hub 214b and the face plates 214a, to cut or tap a complimentary shape from the engaging opposite component.

[0017] Once the three components of the summation lever are assembled to one another, the resulting main body is identical in function to the main body 114 of the prior art. The remaining components that complete the summation lever assembly 210 are installed in much the same way as shown in figure 1c. The hub 214b has an inner bore 230 for receiving the pivot shaft 220. The shaft 220 may or may not be free to rotate inside the inner bore 230. The remaining stamped holes 218 receive the shafts 222a and 222b which support rollers 112a and 112b respectively, in much the same way as the prior art shown in figure 1c. Again the shaft 222a may be retained in the stamped holes 218 by any suitable means but is preferably held by heat shrinking.

[0018] In much the same way as the prior art, the rollers or followers 212a and 212b rotate about the shafts 222a and 222b on roller bearings 226, the pair of rollers 212b each being retained on each outside face of the face plates 214a by caps 224, while the single roller 212a is sandwiched, but free to rotate on roller bearing elements 226, between the two face plates 214a.

Second Embodiment

[0019] Turning now to figures 3a, b and c, the components and construction are much the same as shown in the first embodiment except that the pivot shaft and hub are combined to form a hub pivot shaft 314b to which the face plates 314a are attached as described previously. The pivot shaft is only required to form a rotating connection between the summation lever assembly 310 and the valve actuating lever (not shown). It is therefore unimportant that the hub pivot shaft 314b is prevented from rotating relative to the summation lever body if the valve actuating lever is free to rotate relative to the hub pivot shaft 314b.

[0020] The other components of this embodiment remain unchanged compared with the first embodiment.

[0021] The advantage of forming the summation lever assembly in this way is the reduced part count which leads to a reduction in cost and complexity and reduces the likelihood of failure.

Third Embodiment

[0022] The third embodiment shown in figures 4a, b and c is similar to the second embodiment with the exception that the two face plates 314a of the previous embodiment are replaced by a single pressing folded face plate 414a. This is most clearly shown in the underneath view of figure 4c.

[0023] The folded face plate 414a is pre folded prior to the insertion (as described previously) of the hub pivot shaft 414b. In previous embodiments, the face plates

214a, 314a have been assembled on either axial side of the hub 214b, 314b. Due to the folded over design of the folded face plate 414a, this method of assembly is not possible, and so the hub pivot shaft 414b is driven through both holes 416 in each side of the folded face plate, from one side. For this reason, the widest outer diameter of the hub pivot shaft 414b must be no larger than diameter of the holes 416 (except allowing for interference or heat shrink fitting). This is most clearly seen in figure 4b, whereas in previous embodiments, specifically shown in figure 3b, the outer diameter of the hub pivot shaft 314b is such that it cannot pass through stamped holes 316.

[0024] Again, the advantage of using a folded face plate is a reduction in the number of parts used as well as a greater resistance to twisting. This means that it is less important to prevent rotation of the hub (whether combined with the pivot shaft or not), and so the need to key the hub to the fascia plates can be obviated.

Fourth Embodiment

[0025] The fourth embodiment, shown in figure 5a, b and c, is very similar to the second embodiment except that the fascia plates 514a are made from pressed steel components where the pressing has been formed to provide a flange around at least a portion of the outer edge of the component. This is shown most clearly in section in figure 5b. The flange provides support to the sides of the summation lever 514 and increases its overall stiffness. This enables the reduction of the overall mass of the component (by using a smaller material thickness) compared to other embodiments.

Fifth Embodiment

[0026] This embodiment, shown in figures 6a, b and c, is also very similar to the second embodiment described above. The difference lies in that the valve actuating levers 640 are also an integral component of the assembly. This enables the entire rocker assembly 638 to be pre-assembled prior to insertion in the cylinder head, and attachment to the valves. The valve actuating rocker 640 is retained on the roller bearing and pivot shaft by a retaining end cap 644 which is press fitted into the hub pivot shaft 614b. This is especially beneficial when utilising roller bearings 642 between the valve actuating levers 640 and the combined hub pivot shaft 614b as it simplifies and therefore speeds up assembly.

Sixth Embodiment

[0027] The sixth and final embodiment shown in figures 7a, b and c, is similar to the fifth embodiment described previously except that the end caps 720 not only retain the valve actuating levers but also provide the bearing support surface for the rolling element bearings 742. These are assembled to the hub 714b on the summation

lever assembly 710 preferably by an interference fit.

[0028] An advantage is that the interference fit between the end cap shafts 720 and the hub 714b is designed to locally expand the outer diameter of the hub 714b in the region of the face plates 714a. This can either generate or increase an interference fit between the face plates 714a and the hub 714b.

[0029] A significant advantage of this design over the embodiments shown in figures 6a, b and c, is that the material and heat treatment of the end cap shafts 720 (high hardness, high Carbon content) can be specified independently of the hub 714b (which may require a different material if it is to be welded to the face plates 714a). It is preferable for the hub 714b and the face plates 714a to be made from a softer metal which will aid in their assembly, but by using a harder end cap shaft 720 and hence bearing surface for supporting the roller bearings 742 and the valve actuating levers 740, the functionality and longevity of the complete rocker assembly 738 need not be compromised. The rocker assembly 738 is therefore easier to assemble, less expensive to manufacture, more convenient to install into an engine, and due to the use of roller bearings 742 supporting the valve actuating levers, reduces valvetrain losses, therein increasing engine efficiency.

Claims

1. A rocker system comprising a summation lever and at least one valve actuating lever for use in a valve train of the type having two cams, the summation lever having followers engaging with both cams and the valve actuating lever being pivotally connected to the summation lever for opening and closing an engine valve in dependence upon the sum of the lifts of the two cams,
characterised in that the summation lever is assembled from opposed face plates (214a; 314a; 414a; 514a; 614a; 714a) and a separately formed hub (214b; 314b; 414b; 514b; 614b; 714b).
2. A rocker system as claimed in claim 1, wherein the faceplates (214a; 314a; 414a; 514a; 614a; 714a) are formed of sheet metal.
3. A rocker system as claimed in claim 2, wherein the faceplates (214a; 314a; 414a; 514a; 614a; 714a) are stamped, pressed or forged.
4. A rocker system as claimed in claims 1 to 3, wherein the faceplates (414a) are formed as one folded sheet metal component.
5. A rocker system as claimed in any preceding claim, wherein the hub (214b; 314b; 414b; 514b; 614b; 714a) is secured to each of the pair of face plates (214a; 314a; 414a; 514a; 614a; 714b) by means of

brazing, welding, gluing, heat-shrinking or interference fitting.

6. A rocker system as claimed in any preceding claim, wherein the engaging surfaces between the hub (214b; 314b; 414b; 514b; 614b; 714b) and the face plates (214a; 314a; 414a; 514a; 614a; 714a) are form locking to prevent relative rotation. 5
7. A rocker system as claimed in any preceding claim wherein the hub (214b; 714b) includes a bore (230; 730) for receiving at least one pivot shaft (220; 720). 10
8. A rocker system as claimed in claim 7, wherein the bore (230; 730) of the hub (214b; 714b) is a bearing surface for the pivot shaft (220; 720). 15
9. A rocker system as claimed in claims 1 to 6, wherein the hub (314b; 414b; 514b; 614b) is formed as one piece with an integral pivot shaft. 20
10. A rocker system as claimed in any preceding claim, wherein the face plates (214a; 314a; 414a; 514a; 614a; 714a) are flanged for at least a portion of their circumference to increase their rigidity. 25
11. A rocker system as claimed in any preceding claim, wherein the valve actuating lever (640; 740) is rotatably supported and secured on a shaft (614b; 720) extending from the hub (614b; 714b). 30
12. A rocker system as claimed in claim 11, wherein a roller element bearing (642; 742) is disposed between the shaft (614b; 720) and the valve actuating lever (640; 740). 35
13. A rocker system as claimed in claim 11 or 12, wherein a respective end cap shaft (720) supporting and retaining a valve actuating lever extends from each axial end of the hub (714b). 40
14. A rocker system as claimed in claim 12 or 13, wherein the end cap shaft (720) is retained within an internal bore (730) of the hub (714b) by means of an interference fit. 45
15. A rocker system as claimed in claim 14, wherein formations (744) on the hub (714b) are displaced radially outwards upon forced insertion of the end cap shaft (720) into the hub (714b) increasing the engagement between the hub (714b) and face plate (714a). 50

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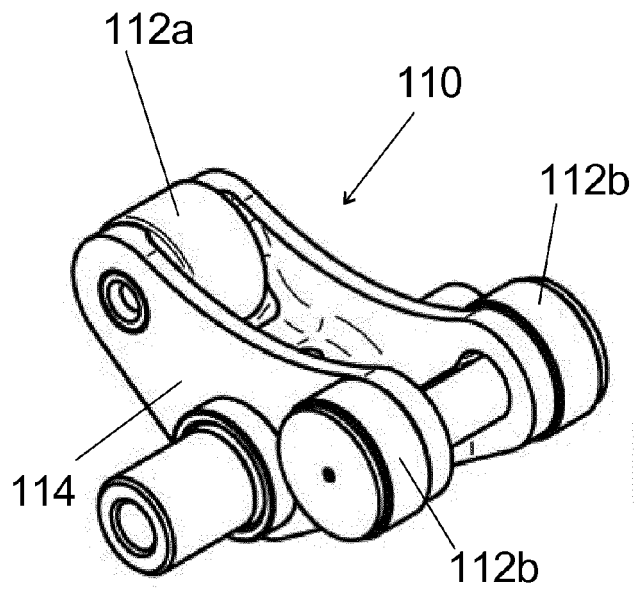


Figure 1a
(Prior Art)

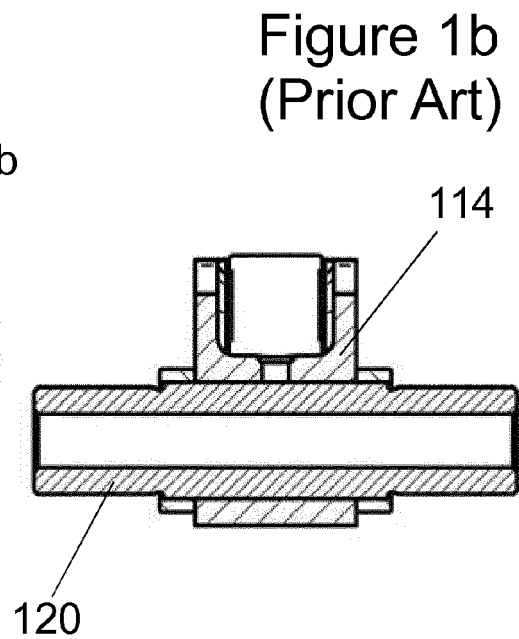


Figure 1b
(Prior Art)

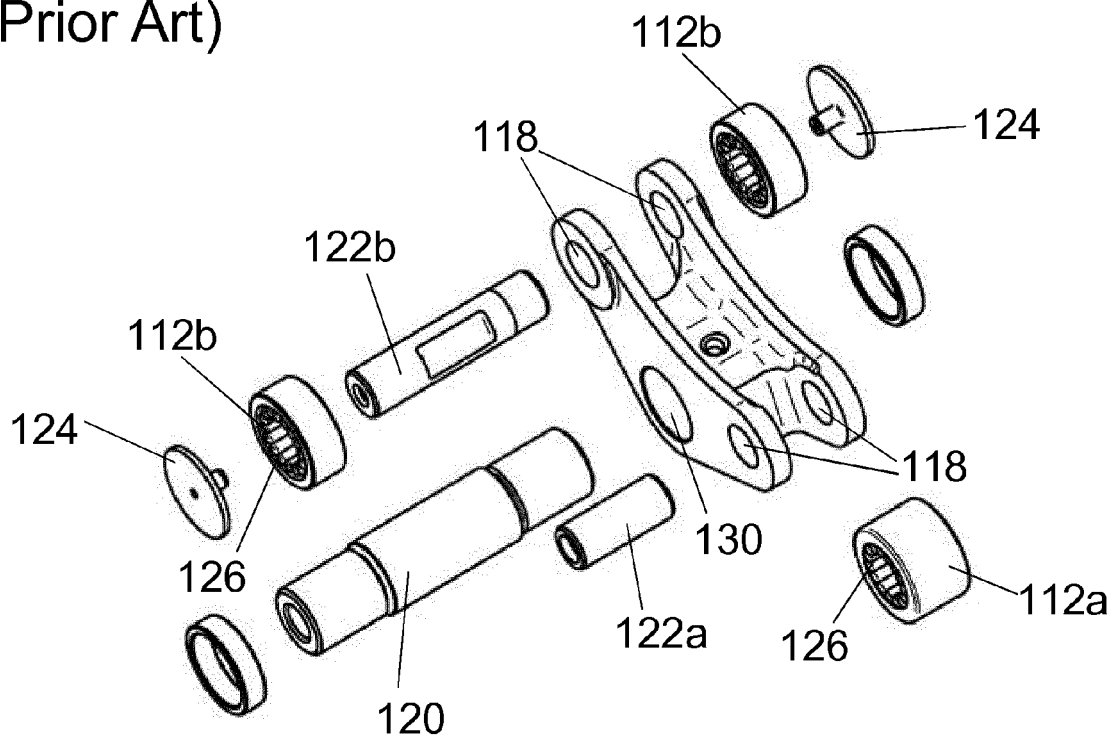
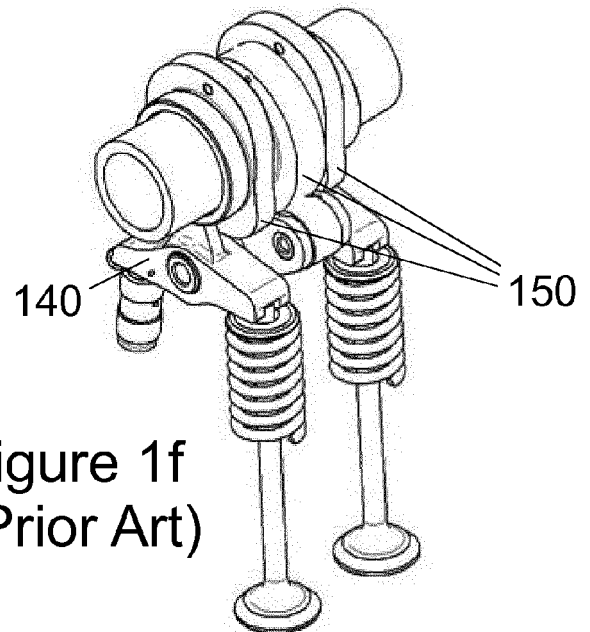
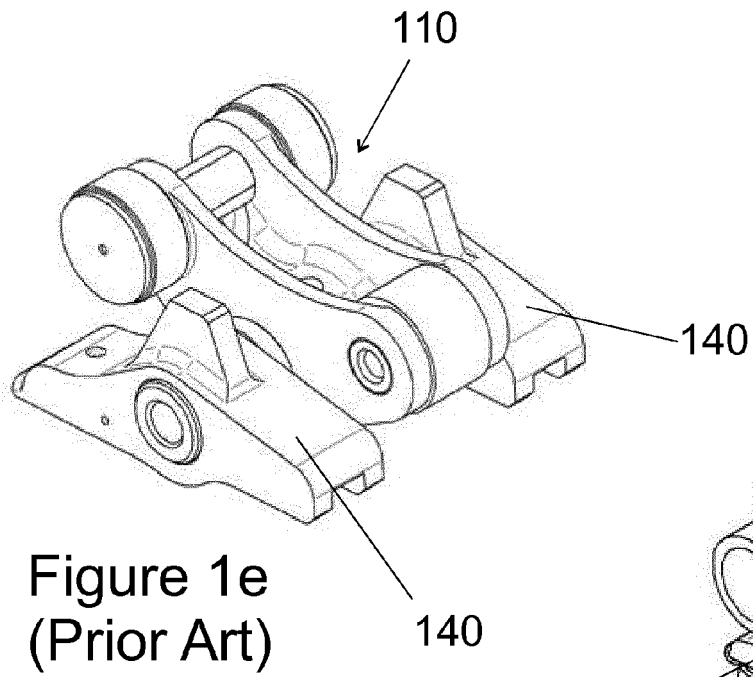
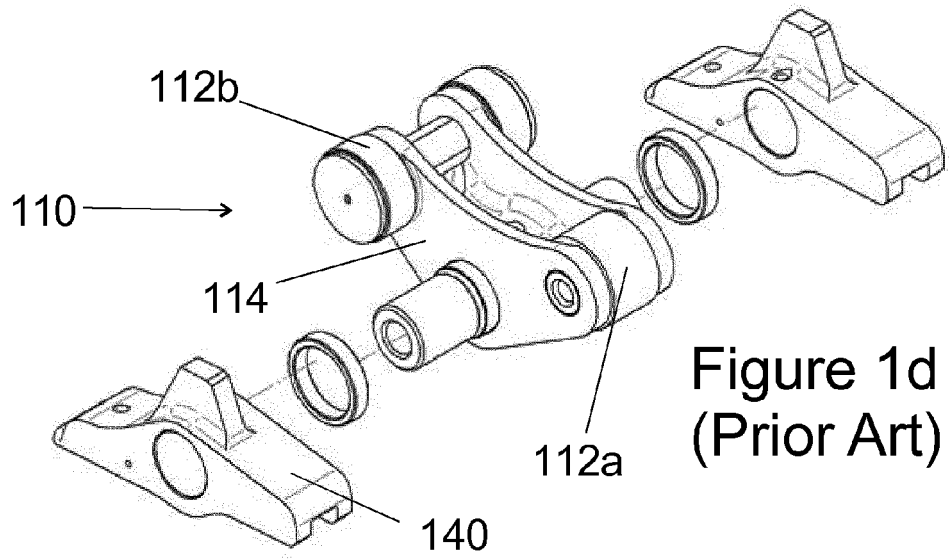


Figure 1c
(Prior Art)



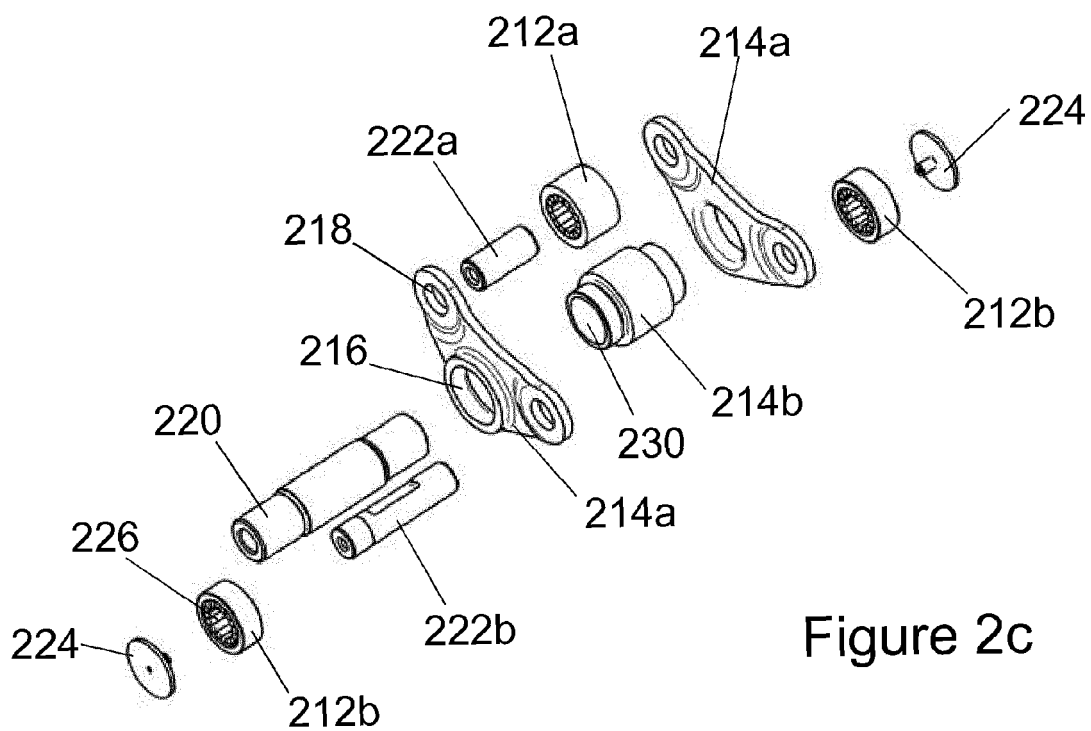
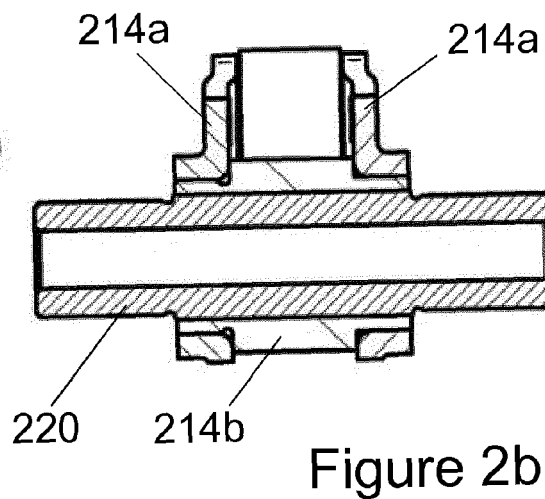
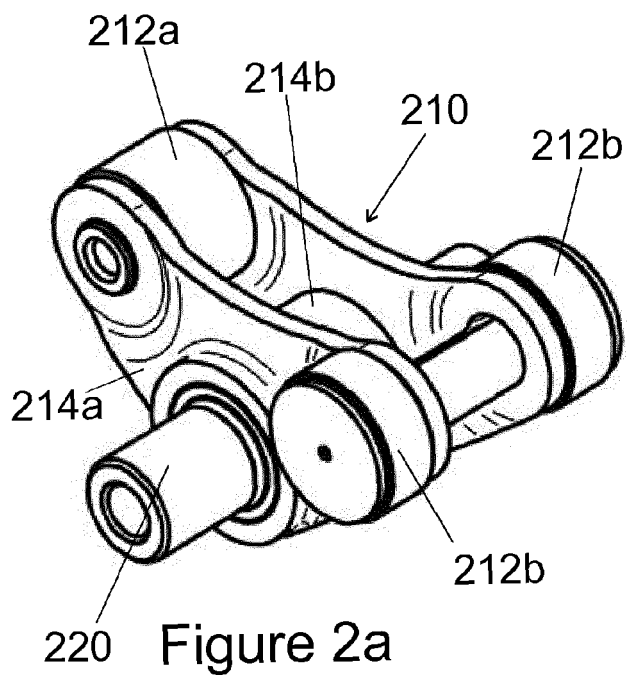


Figure 3a

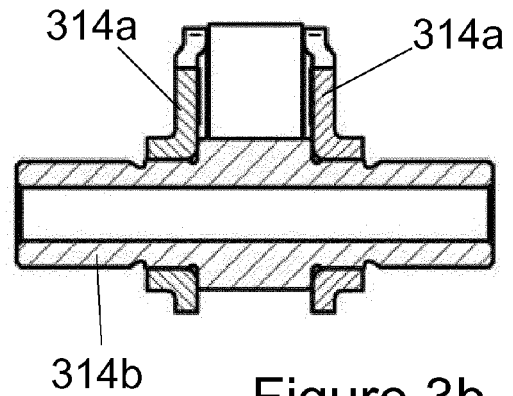
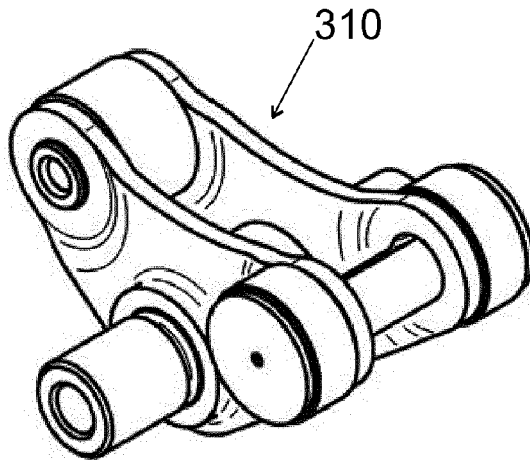


Figure 3b

Figure 3c

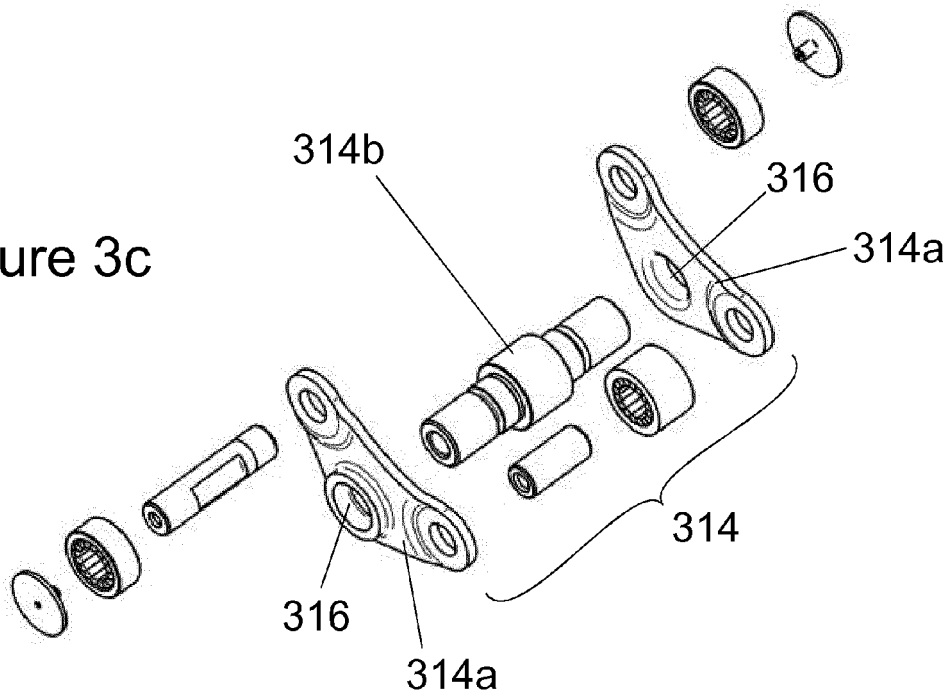


Figure 4a

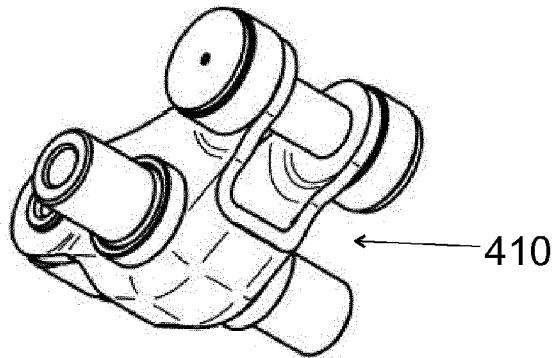
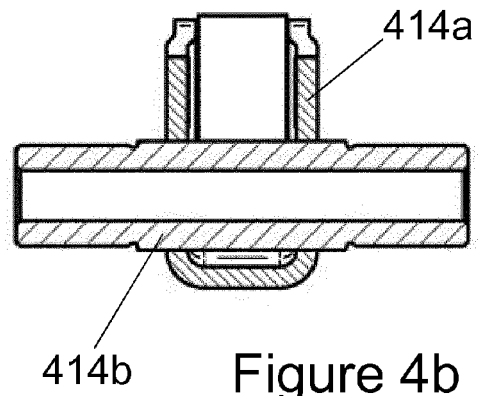
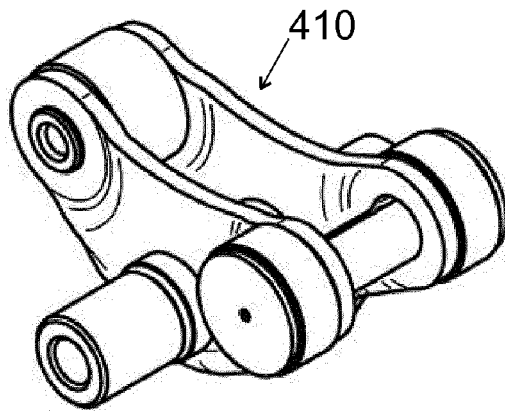


Figure 4c

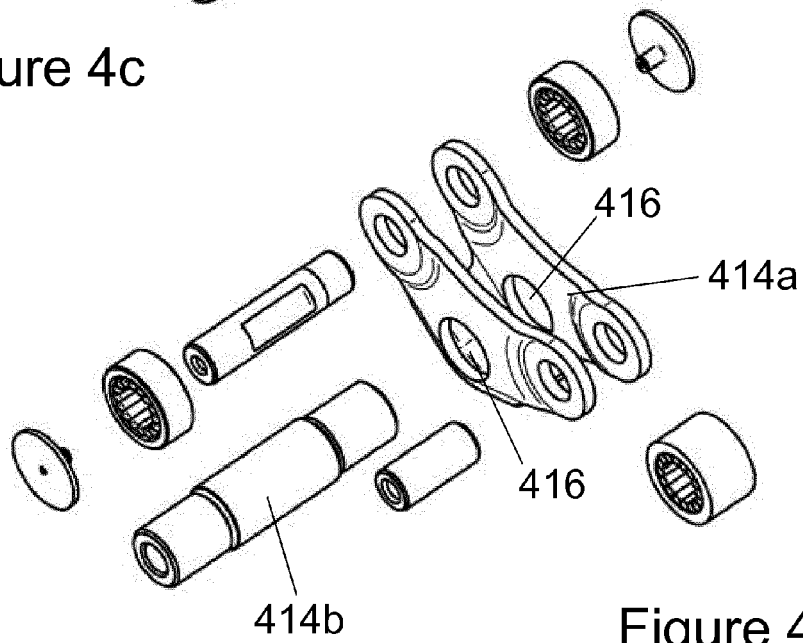


Figure 4d

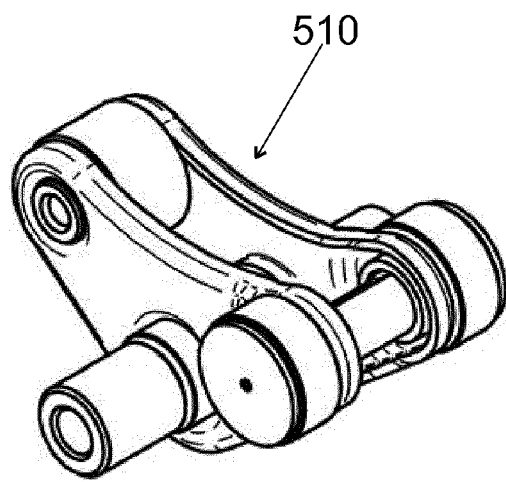


Figure 5a

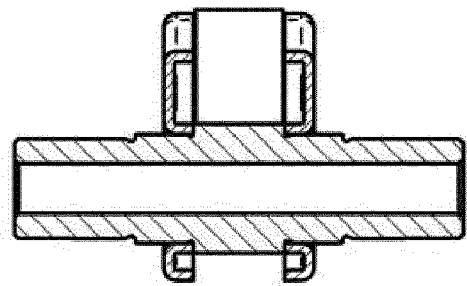


Figure 5b

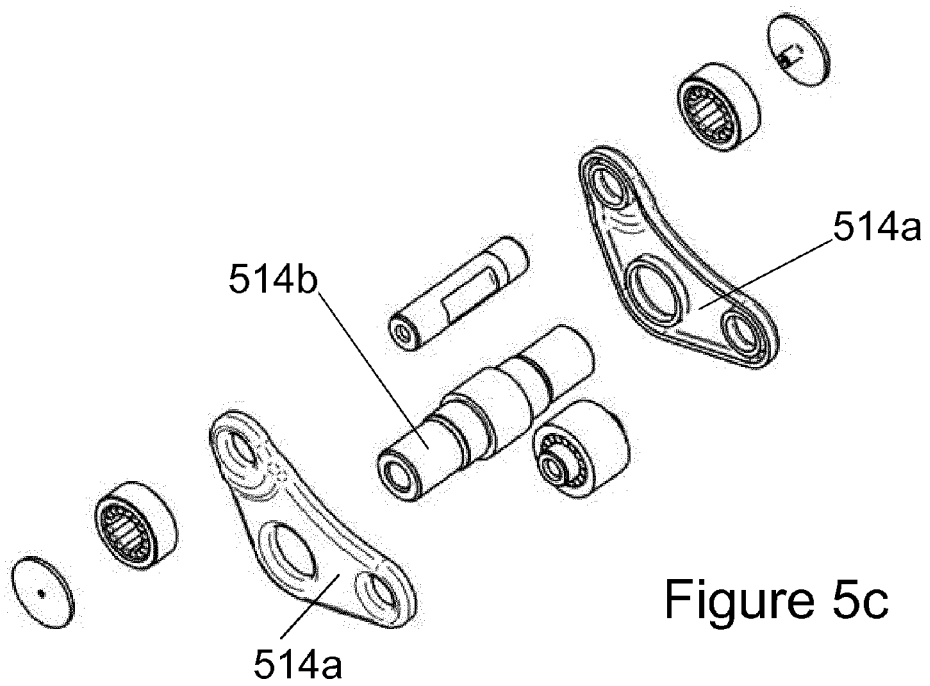


Figure 5c

Figure 6a

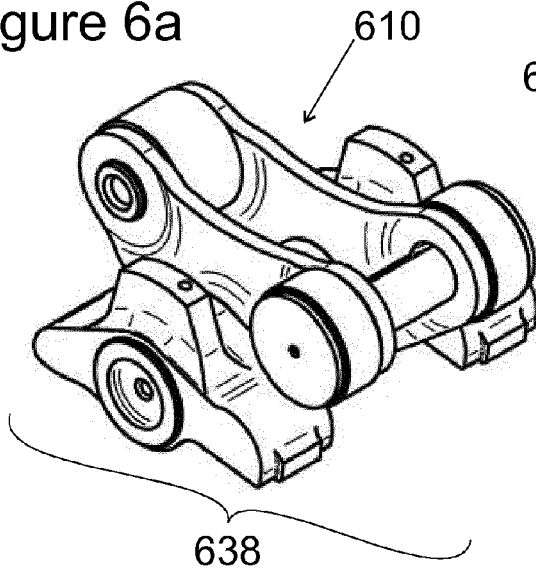


Figure 6b

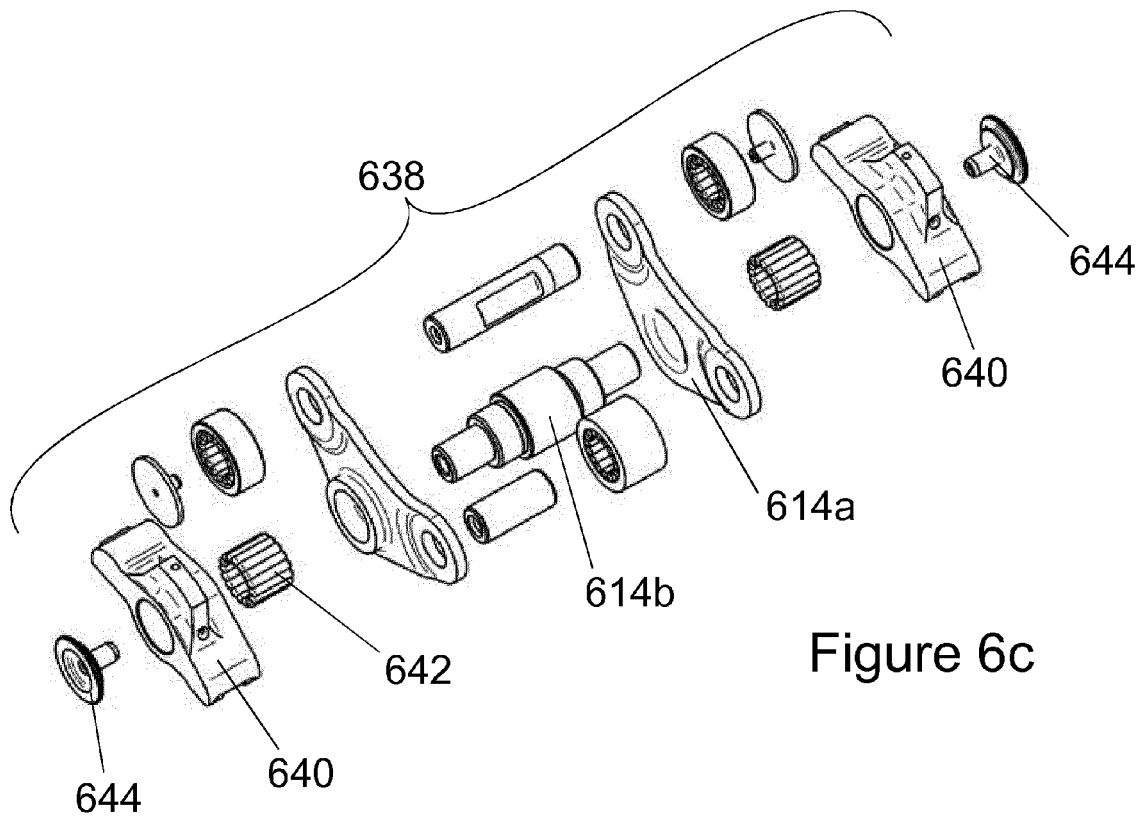
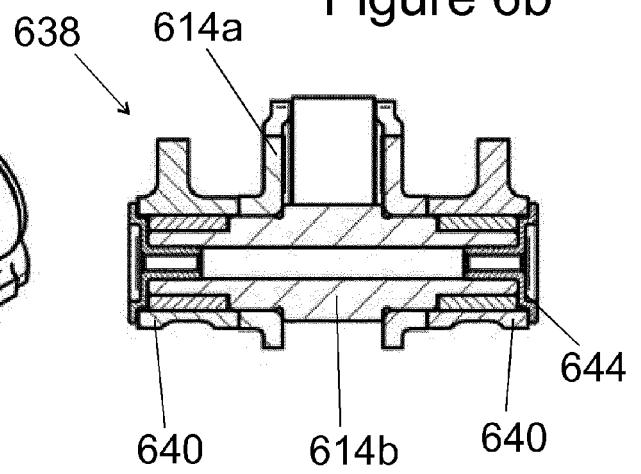


Figure 6c

Figure 7a

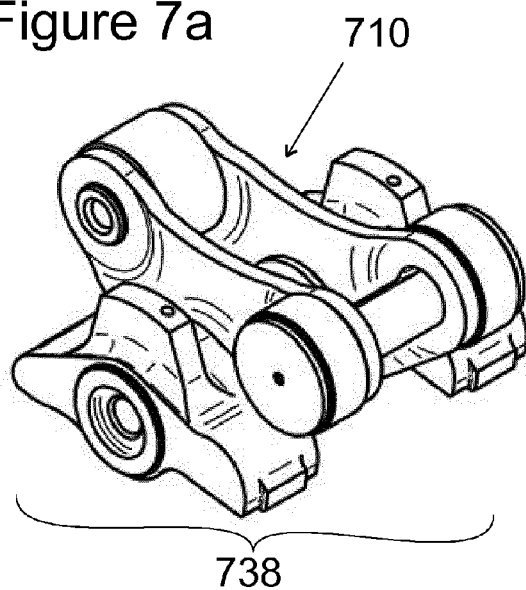


Figure 7b

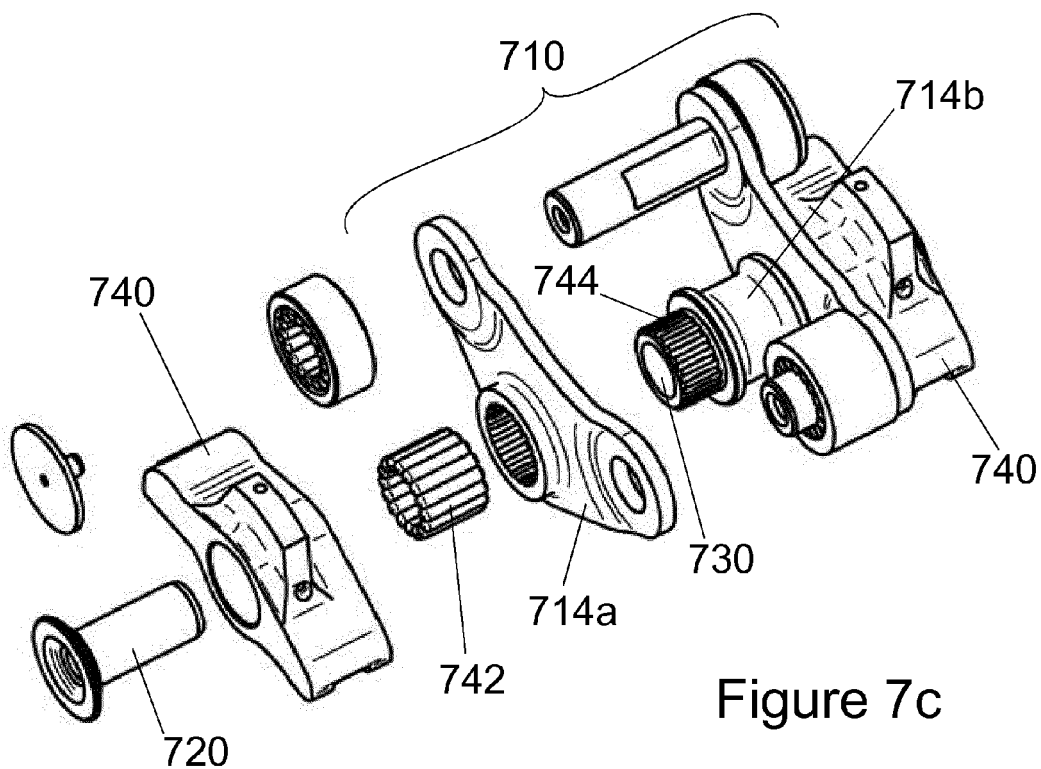
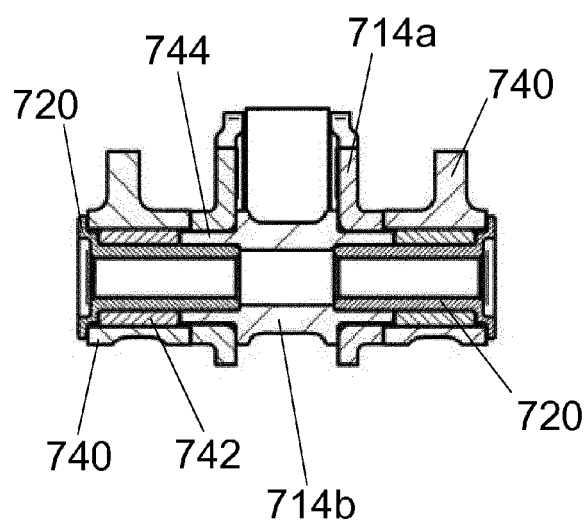


Figure 7c



EUROPEAN SEARCH REPORT

Application Number
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Place of search Munich		Date of completion of the search 25 July 2013	Examiner Paulson, Bo
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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