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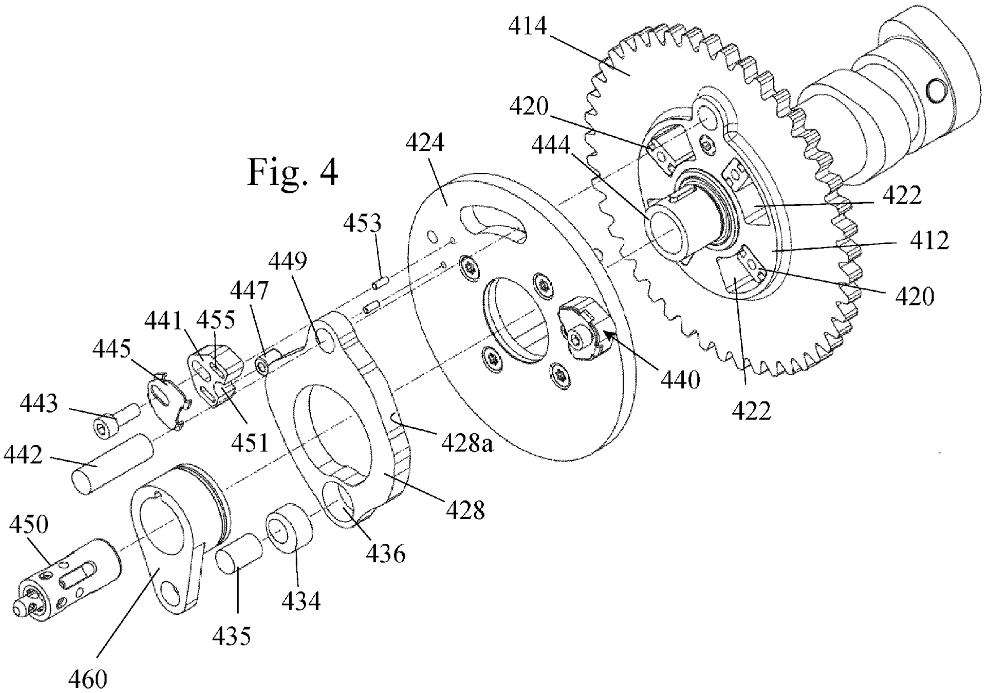
(54) **VARIABLE PHASE MECHANISM**

(57) A yoke-type phaser is disclosed having a drive member and a driven member rotatable about a common axis and coupled to one another by means of a yoke that is movable, in a plane normal to the common axis, to vary the relative phase of the drive and driven members, by interaction between at least two contact elements and a contoured surface. In the invention, each contact element is a rolling element that is freely rotatably supported in a journal with which the rolling element makes surface contact.

Fig. 4



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Description

Field of the invention

[0001] The present invention relates to a variable phase mechanism, also termed a phaser, for use in a valve train of an internal combustion engine to permit variation of the crank angles at which valves of the engine open and close.

Background of the invention

[0002] As is well known, valve timing has a significant effect on engine performance and the optimum setting varies with engine operating conditions. To optimise performance under different operating conditions, it is necessary to be able to vary the valve timing.

[0003] Variable phase mechanisms are known that comprise a shaft, a sleeve journaled on the shaft and fast in rotation with a cam, a coupling yoke connected by a first pivot pin to the shaft and by a second pivot pin to the sleeve and means for causing the yoke to pivot about the first pivot pin to effect a phase change between the shaft and the sleeve. Such mechanisms are herein referred to as yoke-type phasers and examples are to be found in EP0733154 and EP1030035.

[0004] EP2044297 describes a dual phaser that is similar in construction to embodiments of the present invention described below. A dual phaser is one having two output members, driving two different sets of cam lobes, that may either be on separate camshafts or mounted on a common assembled camshaft, and allows the phasing of both sets of cam lobes to be adjusted relative to the phase of the crankshaft. In the latter patent, as is explained below, a vane-type phaser drives one of the sets of cam lobes and a yoke-type phaser drives the other set.

[0005] The present invention is directed to an improvement of yoke-type phasers and though it will be described below by reference to a dual phaser, it is equally applicable to a single phaser.

[0006] Figure 1 of the accompanying drawings is derived from EP2044297 and is described below to explain the problem addressed by the present invention.

[0007] The dual phaser 110 of Figure 1 has a drive member 112 to be coupled for rotation with a crankshaft via a chain engaging sprocket teeth 114. The drive member 112 has a central bore 116 supported by a front bearing 118 of the camshaft. The dual phaser 110 includes a vane-type phaser having vanes 120 which pass through, and seal against, arcuate cavities 122 in the drive member 112 and are secured at their opposite axial ends to front and rear closure plates 124 and 126. The design of the vane-type phaser is generally similar to that shown in GB 2421557, in which it is described in greater detail.

[0008] A yoke 128 is located inside the drive member 112 behind the front plate 124 and is connected to the drive member 112 by a pin 130 which is fixed into a radial bore 132 and engages in a fulcrum pin 134 that fits rotatably into an axially extending bore 136 in the yoke 128. This linkage allows the yoke 128 to rotate about a pin 142 connecting it with the front camshaft bearing 118 and to take up an eccentric position. The yoke 128 is positioned by two pins 140 that are fixed into the front plate 124 of the phaser and engage with the contoured outer profile of the yoke 128. The profile on the radially outer surface of the yoke 128 causes it to rotate about the fulcrum pin 134 as the two pins 140 in the front plate 124 of the phaser rotate with the vanes 120.

[0009] The dual phaser 110 is intended to drive an assembled camshaft (not shown in Figure 1) having an inner shaft and a concentric outer tube, each fast in rotation with a respective set of cam lobes. The outer tube of the camshaft is driven via the front bearing journal 118, which in turn is driven by the yoke 128 via the connecting pin 142. The inner shaft of the camshaft is driven via a threaded shaft 144 that passes through the centre of the phaser 110 and is secured to the front plate 124 via a nut 146.

[0010] The front plate of the phaser is formed of two parts 124a, 124b in order to simplify the oil distribution within the phaser, although a single part with complex oil drillings could alternatively be used. The inner part 124a contacts the ends of the vanes 120 and acts to seal the front of the cavities 122 in the drive member 112, while the outer part 124b acts to seal oil distribution slots 148 that are formed in the inner part 124a. The outer part 124b also has timing features to enable a sensor to detect the position of the phaser during operation. Four vane fixings and the central drive shaft nut 146 all act to clamp the two parts together.

[0011] Figures 2a, 2b and 2c show sections through drive member 112 and yoke 128 the phaser of Figure 1 in three different positions. In Figure 2a, corresponding to mid-range, the yoke 128 is in a concentric position, whereas in Figures 2b and 2c the vanes 120 are fully retarded and fully advanced, respectively. It can be seen that the pin 142 in the yoke 128, that connects it to the front bearing and hence the outer tube of the camshaft, moves around the camshaft centre in the opposite direction to the vanes 120 and also moves through a different angle from the vanes 120.

[0012] Although the phaser 110 as shown illustrates the yoke 128 causing the camshaft outer tube to rotate in the opposite direction to its inner shaft, it is possible for the profile of the radially outer surface of the yoke 128 to be changed such that the two camshaft parts rotate in the same direction but by different amounts. The movement of the two phaser outputs may have a linear or nonlinear relationship, but there can only be one yoke position for any given vane position.

[0013] The output of the vane-type phaser causes a sliding of contact to move along a contoured surface. In the case of the embodiment of Figure 1, the contact elements are the pins 140 and the contoured surface is the perimeter surface of the yoke 128, but it is alternatively possible for the yoke to carry elements that slide on a surrounding inwardly facing surface.

[0014] The yoke-type phaser provides a phase-output that is proportional to the vane-type phaser but can be of a different speed, magnitude, and direction, with the ability to also reverse direction through its range relative to its input.

[0015] Problems have hitherto been encountered with yoke-type phasers in balancing the phasing response in both advance and retard directions. These problems have resulted from (i) friction between the contact elements and the contoured surface and (ii) resistive torques of the camshaft, particularly when the yoke-output can reverse direction relative to its input.

[0016] In accordance with a first aspect of the invention, there is provided a yoke-type phaser, having a drive member and a driven member rotatable about a common axis and coupled to one another by means of a yoke that is movable, in a plane normal to the common axis, to vary the relative phase of the drive and driven members, by interaction between at least two contact elements and a contoured surface, characterised in that each contact element is a rolling element that is freely rotatably supported in a journal with which the rolling element makes surface contact.

[0017] The first aspect of the invention is concerned with the reduction of friction. In place of the pins 140 that slide on the contoured outer surface of the yoke 128, the invention proposes the use of rollers. It is, however, not sufficient, for example, to provide rollers resting in a V-shaped recess as this would only provide line contact. This would result in high pressures and therefore high frictional forces. Instead, the rollers in the first aspect of the invention need to make surface contact with their support journals, to permit their free rotation.

[0018] In some embodiments, the invention provides a dual phaser for connecting a drive member to first and second driven members, comprising a first phaser connecting the drive member to the first driven member and a yoke-type phaser as set out above connecting the drive member to the second driven member, wherein one of (i) the contact elements and (ii) the contoured surface is connected for rotation with the first driven member and the other is mounted on the yoke.

[0019] The first phaser may conveniently be a vane-type phaser.

[0020] The contact elements may be rollers that are freely rotatable about fixed axles.

[0021] It is important to set the clearances in the phaser correctly to maintain the contact elements in permanent contact with the contoured surface with application of a high force. When the contact elements are rollers mounted on fixed axles, the clearances between the rollers and the contoured surface may be set by appropriate sizing of the rollers. By "appropriate sizing", it is meant that the rollers may be selected from a set of different rollers having different diameters.

[0022] In alternative embodiments, each contact element may comprise a roller in surface contact with part-cylindrical recess in a carrier. In such embodiments, the clearances between the rollers and the contoured surface may be set by appropriate sizing of the carriers or by adjustably mounting the carrier of at least one of the contact elements.

[0023] In order for the response of the dual phaser to be substantially the same both when advancing and retarding the different driven members, each of the two phasers may be provided with a respective bias spring to counteract resistive torques of the respective driven member.

Brief description of the drawings

[0024] The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

- Figure 1, as earlier described, shows an exploded view of a dual phaser known from EP2044297,
- Figures 2a, 2b and 2c are earlier described sections through the dual phaser of Figure 1,
- Figure 3 is a schematic view of two separate camshafts driven by means of a common dual phaser,
- Figures 4 and 5 are exploded views similar to that of Figure 1 showing two embodiments of the invention,
- Figures 6, 7 and 8 show detail views of three further embodiments of the invention, and
- Figure 9 is a section through a detail of the embodiment of Figure 8.

Detailed description of the drawings

[0025] The invention will be described below by reference to dual phasers driving two different sets of cam lobes. The dual phasers will be described as being connected to an assembled camshaft, with one output member driving the inner shaft and the other the outer tube of the assembled camshaft. It should however be clear that all dual phasers may be used to drive two separate camshafts, as is schematically show in Figure 3.

[0026] In Figure 3, a vane-type phaser 300 has an output connected to a first camshaft 310. The vane-type phaser 300 has a second output connected to a yoke-type phaser 320 that in turn drives a cog 330 in mesh with a second cog 340 driving the second camshaft 350. Thus, in the prior art dual phaser of Figure 1, instead of driving the bearing ring 118 that is connected to the outer tube of an assembled camshaft, it may be used to drive a cog of a gear train leading to a separate camshaft.

[0027] Figure 4 of the drawings is an exploded view of a dual phaser of similar construction to the prior art dual phaser of Figure 1 and, to simplify the description and help avoid repetition, components serving like functions in all the embodiments described below have been allocated reference numerals with the same last two significant digits.

[0028] The camshaft in Figure 4 is an assembled camshaft comprising an inner shaft surrounded by an outer tube and having two sets of concentric cam lobes, one set being fast in rotation with the outer tube and the other set being rotatable relative to the outer tube and connected for rotation with the inner shaft by means of pin passing through circumferentially elongated slots in the outer tube. As with the dual phaser of Figure 1, the dual phaser of Figure 4 has a vane-type phaser driving one set of cam lobes and a yoke-type phaser driving the second set of cam lobes. The dual phaser of Figure 4 differs from that shown in Figure 1 in that the vane-type phaser is used to drive the outer tube of the assembled camshaft and the yoke-type phaser drives its inner shaft.

[0029] The input member 412 of the dual phaser in Figure 4 is connected to a cog 414, rather than a sprocket, that is driven by the engine crankshaft. The input member has four arcuate cavities 422 each receiving a respective vane 420 that separates the cavity into two separate working chambers. Oil supplied to the working chambers through a spool valve 450 can move the vanes 420 tangentially from one end of the cavity to the other.

[0030] The vanes 420 are connected to two end plates 424 of which only one is seen in the drawing. The two end plates 424 seal the working chambers of the arcuate cavities 422 and serve as the output member of the first, vane-type, phaser. The output member of the vane-type phaser serves to drive the outer tube of the assembled camshaft to vary the phase of the first set of cam lobes relative to the crankshaft.

[0031] The inner shaft of the assembled camshaft is bolted to a tubular member 444 onto which a crank arm 460 is keyed. Rotation of the crank arm 460 about the axis of the camshaft serves to change the phase of the inner shaft of the camshaft relative to the engine crankshaft.

[0032] The crank arm 460 is connected to the yoke 428 by way of a fulcrum pin 435 and an eccentric sleeve 434 rotatably received in a hole 436. The diametrically opposite side of the yoke 428 is connected by a pivot pin 442 to the input member 412 of the dual phaser. Pivoting of the yoke 428 about the pin 442 causes the hole 436 to pivot about the axis of the pin 442 and thereby cause the crank arm 460 to rotate in order to change the phase of the inner shaft of the camshaft relative to the input member 412, the latter being driven directly by the engine crankshaft. The eccentric sleeve 434 is required because the distance of the pin 435 from the axis of rotation of the yoke changes as the yoke pivots about the pin 442.

[0033] The angular position of the yoke 428 relative to the input member 412 is dictated by the angular position of the end plate 424, serving as the output member of the vane-type phased. To this end, the end plate 424 includes two contact elements, generally designated 440, in contact with the contoured outer surface 428a of the yoke 428. In Figure 4, one of the contact elements 440 is shown in an assembled state and the other in exploded view. The contact elements 440 each comprise a roller 447 journaled in, and making surface contact with, a part-cylindrical recess 451 in a carrier 441. The carrier 441 is secured to the end plate 424 by means of a screw 443 passing through a washer plate 445 and an elongate slot in the carrier 441. Pins 453 engaging in the end plate 424 and in elongate slots 455 in the carrier 441 ensure correct orientation of the carrier 441 while permitting adjustment of the distance of the roller 447 from the contoured surface 428a.

[0034] The journaled rollers 447 that engage the contoured surface 428a in Figure 4 offer less frictional resistance than the pins 140 of the dual phaser of Figure 1 and furthermore the adjustability of their position on the end plate 424 ensures that the clearance between the rollers 447 and the contoured surface 428a can be set accurately.

[0035] The embodiment of the invention shown in Figure 5 demonstrates that the members to which the contact elements and the contoured surface are connected are interchangeable. Thus, in Figure 5 the contact elements 540 are carried by the yoke 528 and the contoured surface is an inwardly facing cam surface 570a of disc 570 secured to the end plate 524 of the vane-type phaser. The construction of the vane-type phaser is not shown in Figure 5 but is the same as that in Figure 4.

[0036] In this case, the roller 547 is journaled in, and makes surface contact with, a part-cylindrical recess 551 a carrier 541 that slides in a channel 555 in the yoke 528. The clearance in this embodiment is set by appropriate sizing of the carriers 541.

[0037] Figure 5 also shows that the dual phaser may comprise two bias springs 582 and 584 to counteract resistive torques of the respective driven members. The spring 582 acts on the crank arm 560 by way of a plate 586 and hence on the output member of the yoke type phaser. By contrast, the spring 584 acts on a plate 590 carrying timing features and secured to the output member of the vane-type phaser.

[0038] The embodiments of Figures 6 and 7 are essentially the same as that of Figure 5 save for the construction of the contact elements.

[0039] In Figure 6, instead of sizing the carriers to set the clearance, carriers 641 of fixed size are used and a shim 661 is disposed between one or both of the carrier 641 and the bottom of the channel 655.

[0040] Figures 6 and 7 also show an alternative connection between the yoke 628 and the crank arm 660 in that instead of an eccentric sleeve the fulcrum pin 635 is slidable on radial projection of the crank arm 660.

[0041] In Figure 7, each contact element is a roller 747 that is freely rotatable about an axle pin 781 held in holes 783 in two cheeks defined by the yoke 728. In this case, one or both of the rollers 747 may be sized to set the desired clearance.

[0042] Figures 8 and 9 show a still further embodiment of the invention in which a hydraulic lash adjuster 893 is used in place of a shim, the embodiment being otherwise the same as that of Figure 6. Hydraulic lash adjusters are of course well known and rely on oil pressure to set a minimal clearance. Figure 9 shows that an oil drilling may be provided in the yoke 828 for this purpose but lash adjusters are better suited to embodiments in which the contoured surface is on the perimeter of the yoke.

Claims

1. A yoke-type phaser, having a drive member and a driven member rotatable about a common axis and coupled to one another by means of a yoke that is movable, in a plane normal to the common axis, to vary the relative phase of the drive and driven members, by interaction between at least two contact elements and a contoured surface, **characterised in that** each contact element is a rolling element that is freely rotatably supported in a journal with which the rolling element makes surface contact.

2. A dual phaser for connecting a drive member to first and second driven members, comprising a first phaser connecting the drive member to the first driven member and a yoke-type phaser as claimed in claim 1 connecting the drive member to the second driven member, wherein one of (i) the contact elements and (ii) the contoured surface is connected for rotation with the first driven member and the other is mounted on the yoke.

3. A dual phaser as claimed in claim 2, wherein the first phaser is a vane-type phaser.

4. A dual phaser as claimed in claim 2 or claim 3, wherein the contact elements are rollers freely rotatable about fixed axles and, in order to set the clearances between the rollers and the contoured surface, the rollers are appropriately sized.

5. A dual phaser as claimed in claim 2 or claim 3, wherein each contact element comprises a roller in surface contact with part-cylindrical recess in a carrier.

6. A dual phaser as claimed in claim 5, wherein in order to set the clearances between the rollers and the contoured surface, the carriers are appropriately sized.

7. A dual phaser as claimed in claim 5, wherein in order to set the clearances between the rollers and the contoured surface, the carrier of at least one of the contact elements is adjustably mounted.

8. A dual phaser as claimed in claim 7, wherein the position of the carrier of at least one of the contact elements is adjustable by means of shims.

9. A dual phaser as claimed in claim 7, wherein the carrier of at least one of the contact elements is retained in position by means of a screw passing through an elongate slot in the carrier.

10. A dual phaser as claimed in claim 7, wherein the position of the carrier of at least one of the contact elements is adjustable by means of a hydraulic lash adjuster.

11. A dual phaser as claimed in any one of claims 2 to 10, wherein each of the two phasers is provided with a respective bias spring to counteract resistive torques of the respective driven members.

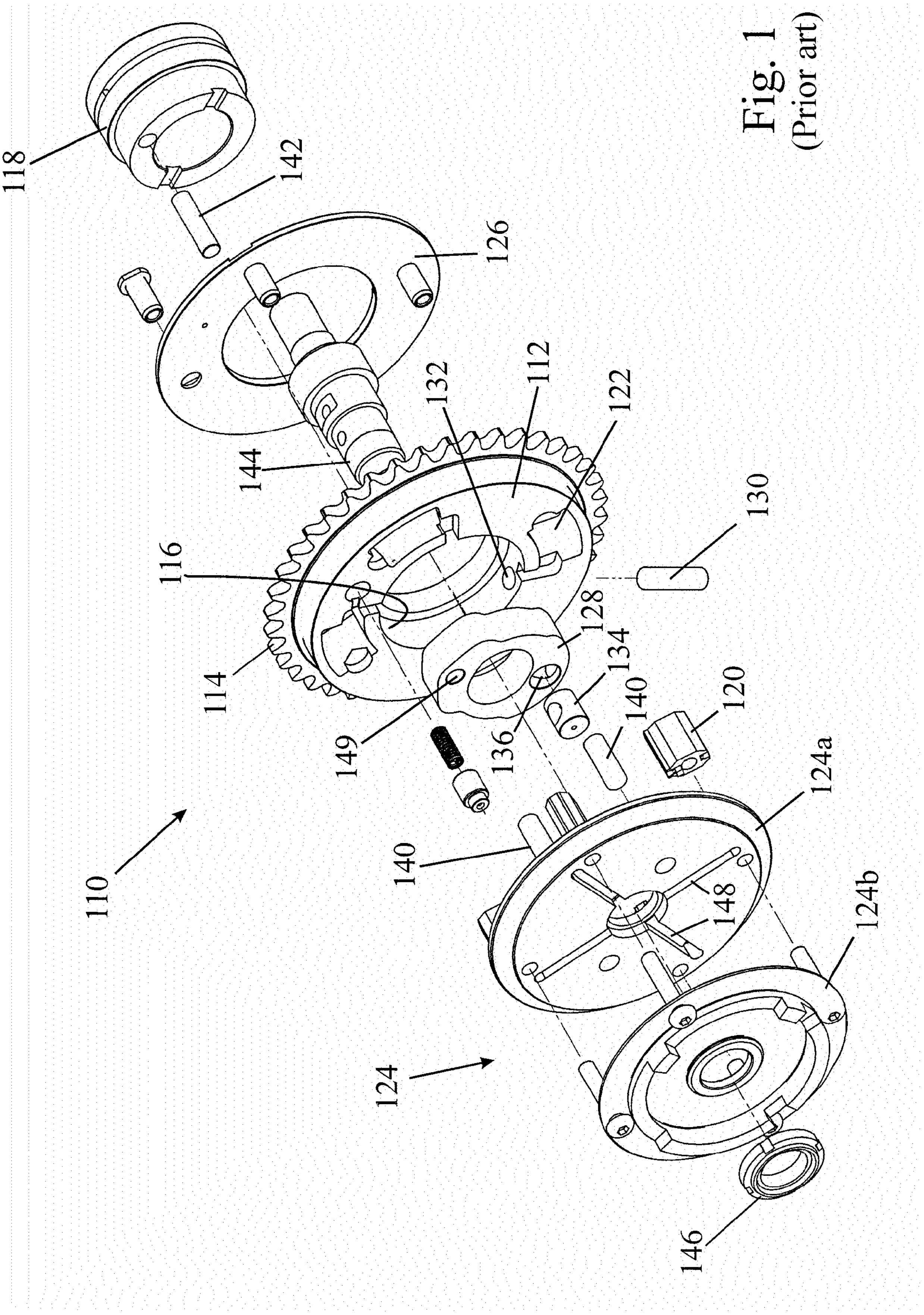

Fig. 1
(Prior art)

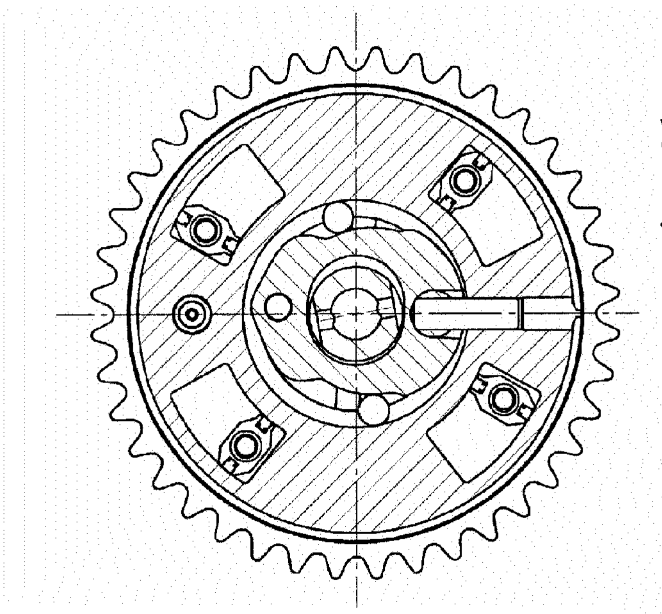

Fig. 2b
(Prior art)

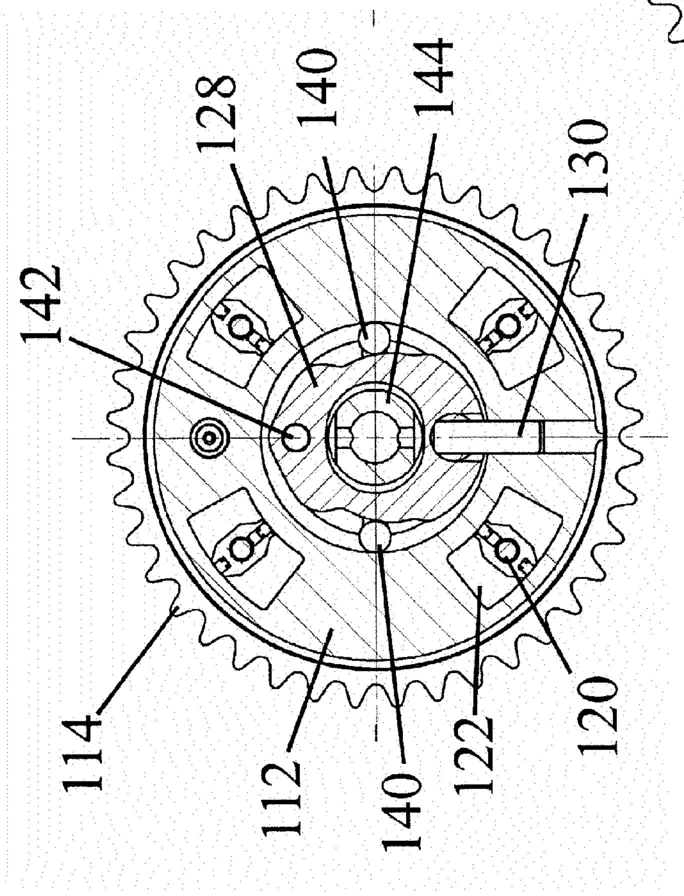

Fig. 2a
(Prior art)

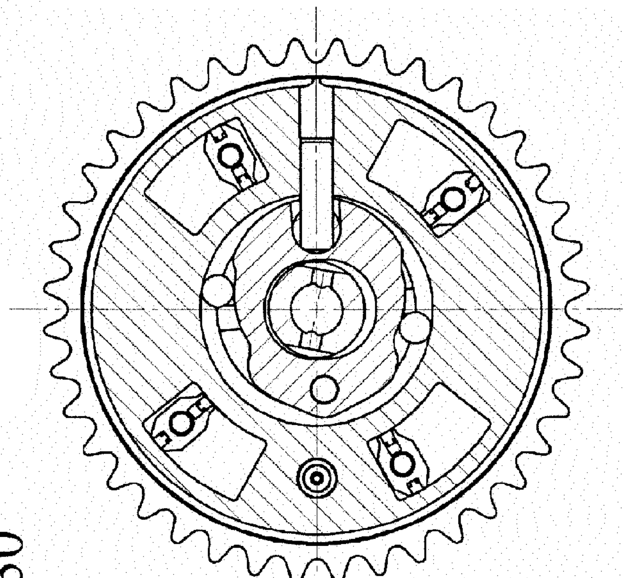

Fig. 2c
(Prior art)

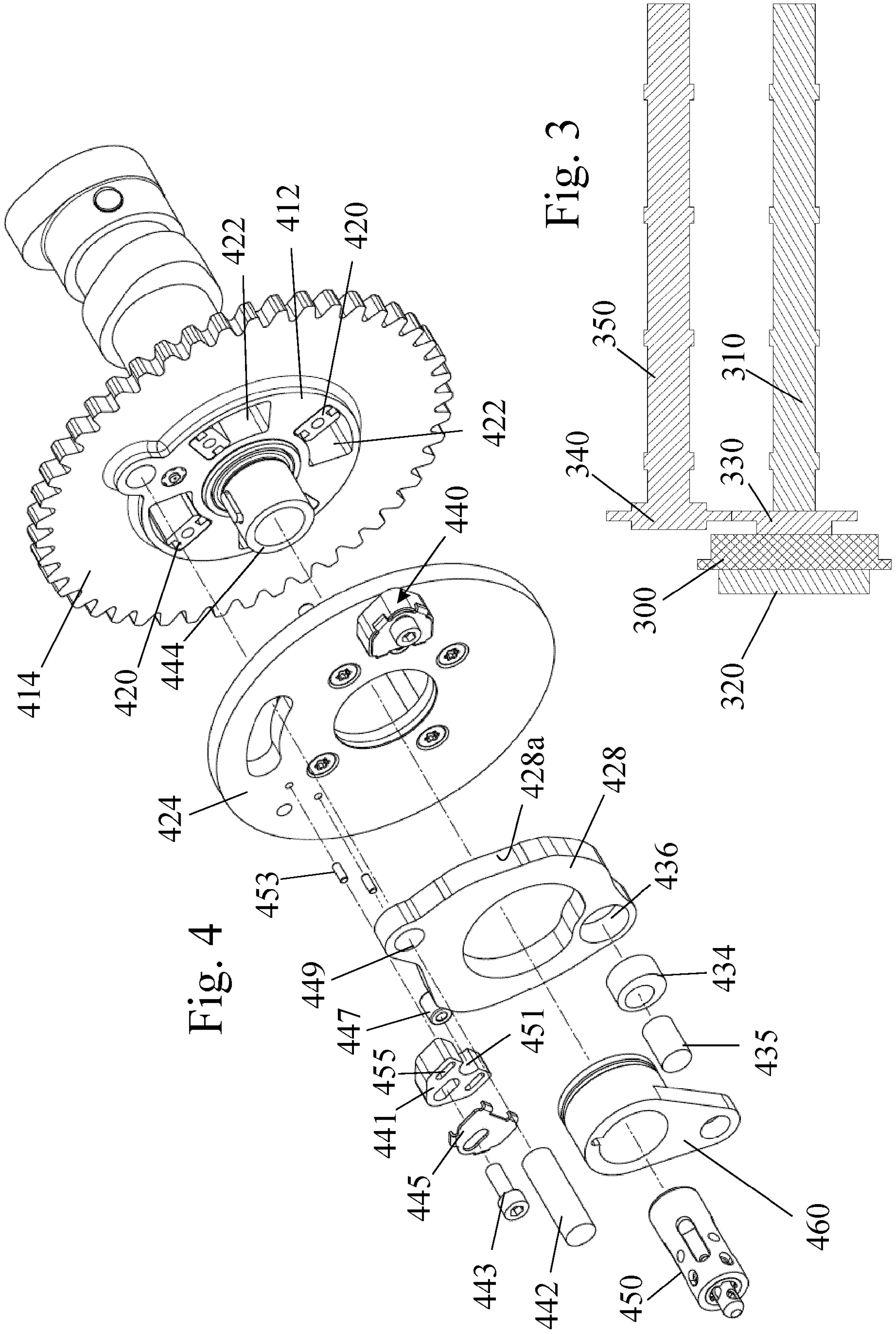
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Fig. 3

Fig. 4

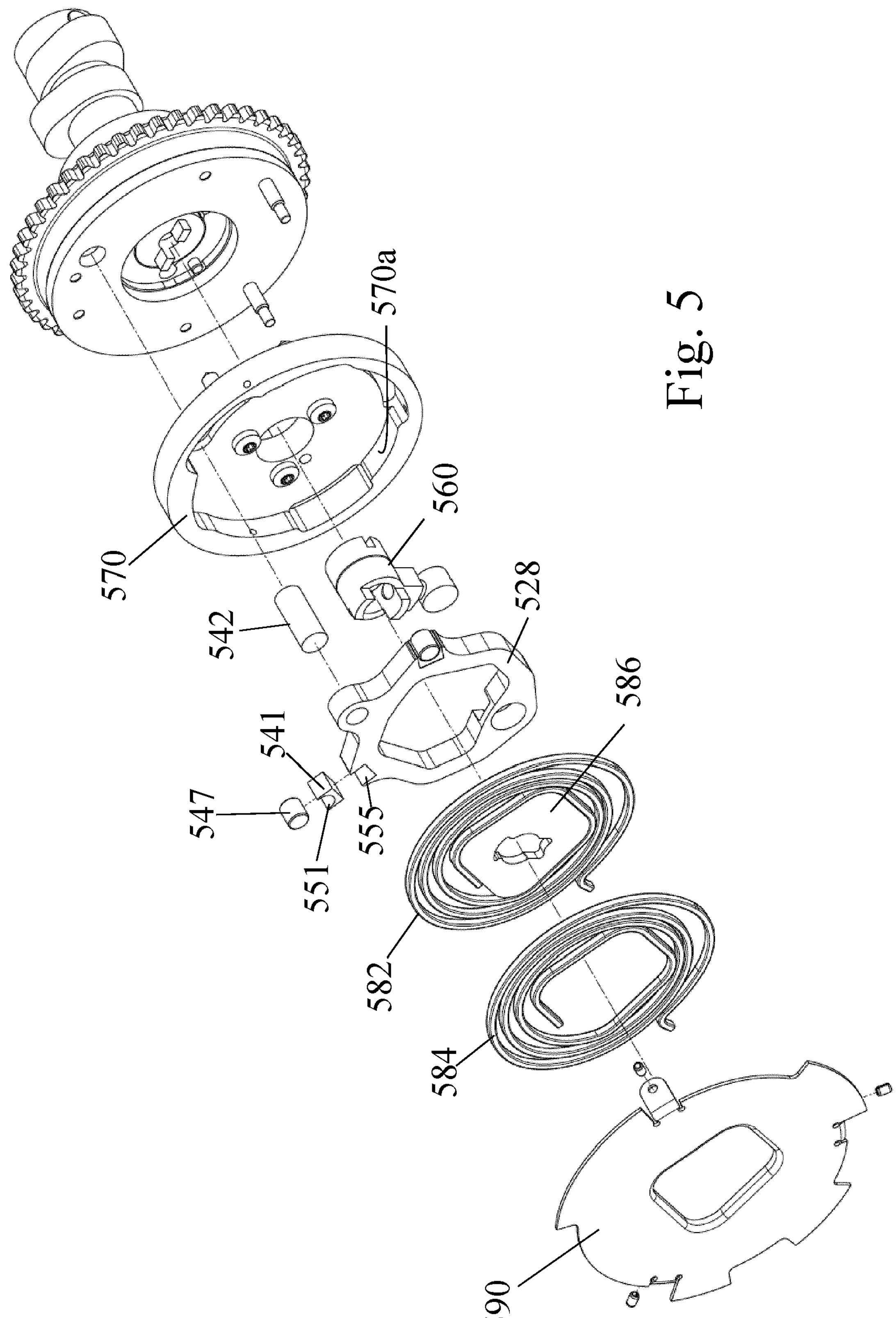

Fig. 5

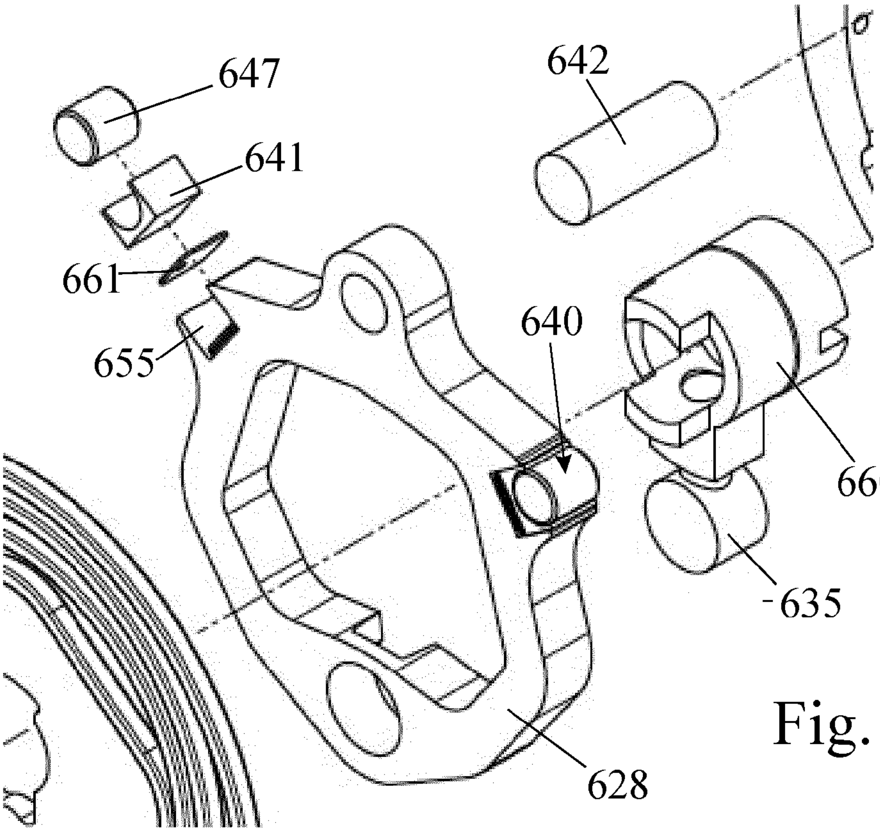

Fig. 6

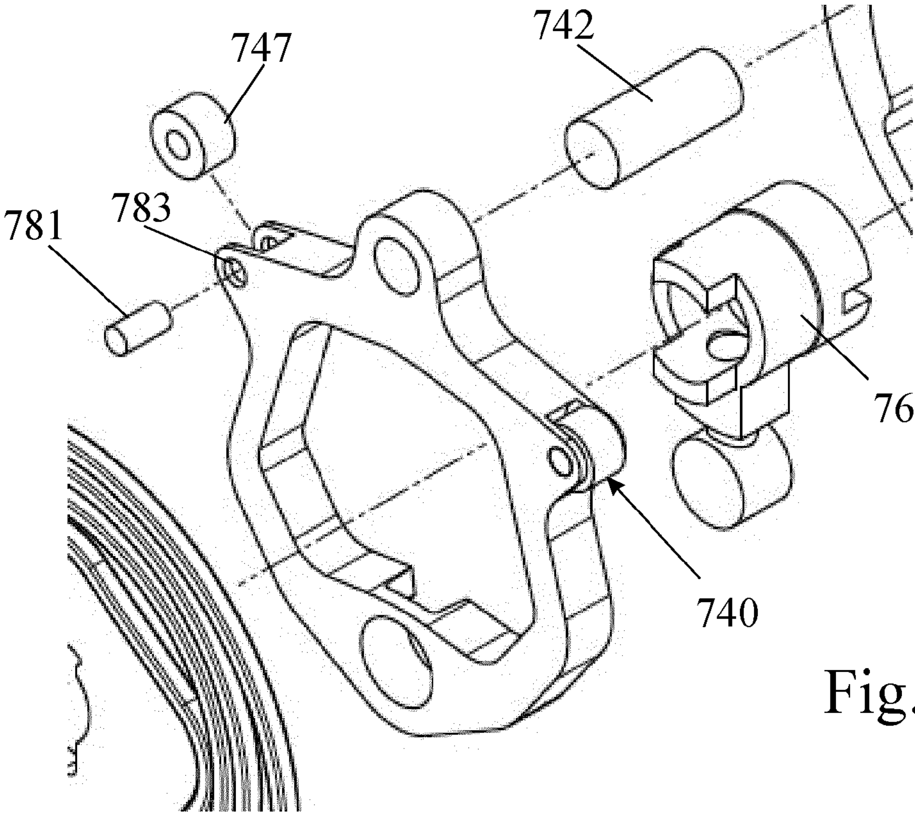

Fig. 7

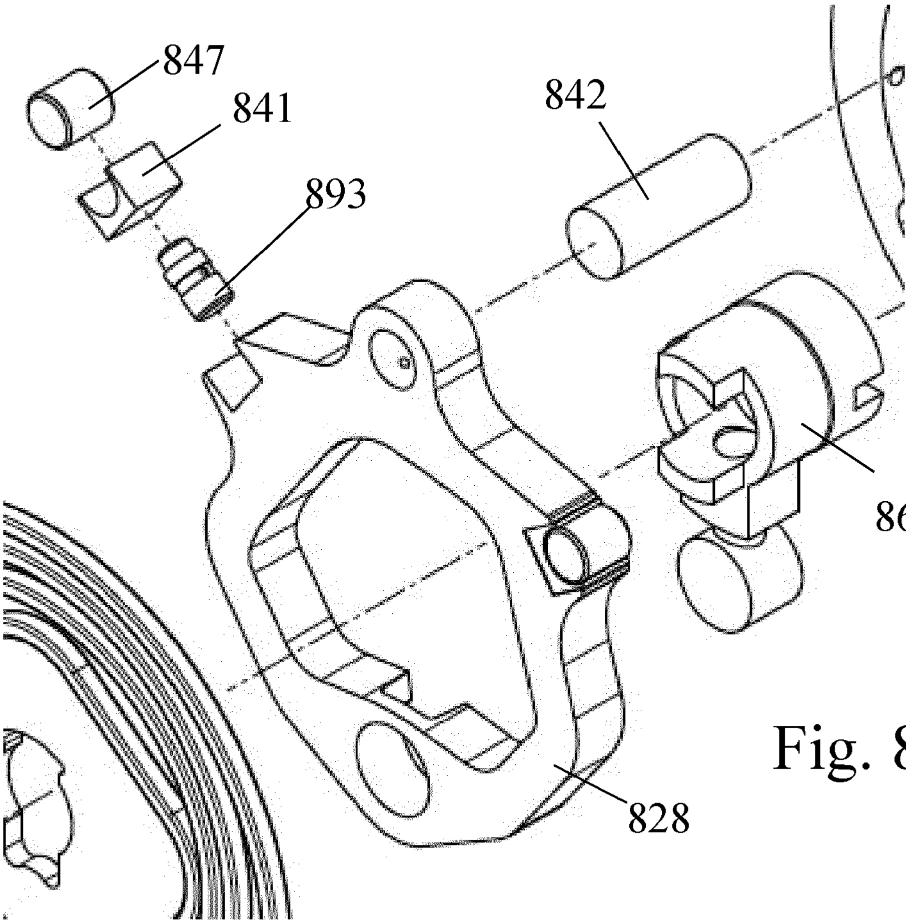

Fig. 8

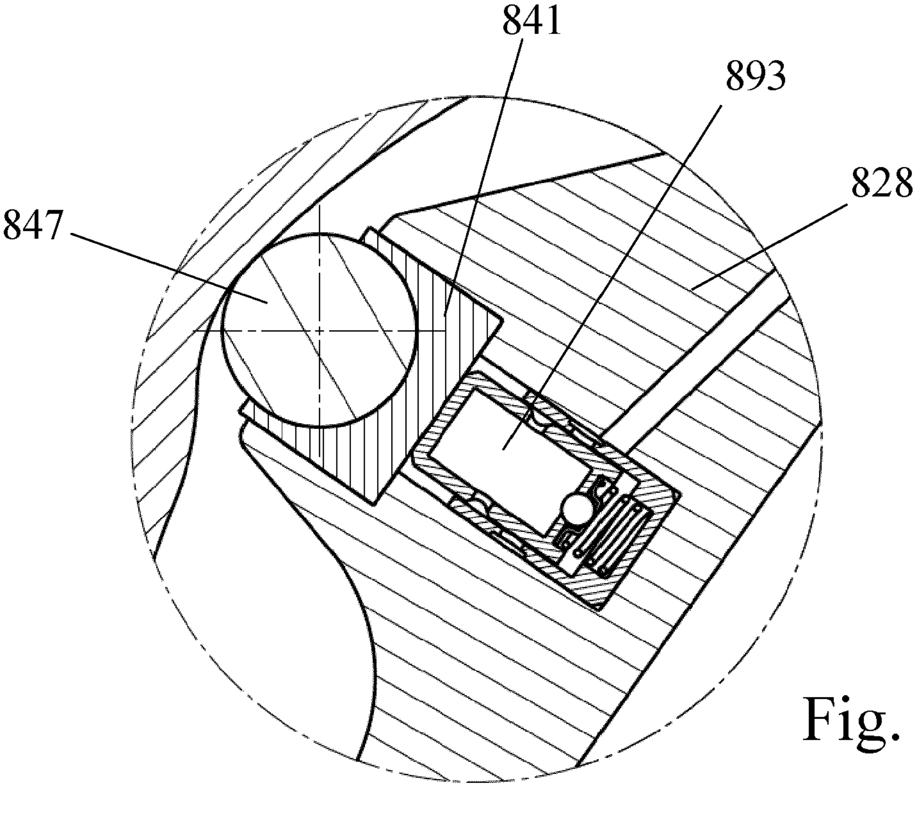

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 8295

DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US 2019/242277 A1 (MCCLOY CHAD [US] ET AL) 8 August 2019 (2019-08-08) * abstract; figures 1-4 * * paragraph [0016] - paragraph [0021] * -----	1-11	TECHNICAL FIELDS SEARCHED (IPC) F01L

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	22 November 2021	Van der Staay, Frank

CATEGORY OF CITED DOCUMENTS

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