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(54) ENGINE WITH A CONCENTRIC CAMSHAFT

(57) An engine with an adjustable camshaft assembly (50) is disclosed having first (56) and second (58) groups of cam lobes and an actuator ('10) for varying the phase of at least one of the groups of cam lobes (56,58) relative to a crankshaft of the engine. The camshaft assembly (50) is of the type known as a concentric camshaft and the actuator ('10) comprises a drive member ('14a, '14b) and one or more driven members ('20) that are rotatable relative to the drive member, the groups of cam lobes of the adjustable camshaft assembly each being connected for rotation with a respective one of the drive member and the driven member(s) of the actuator. In the invention, the actuator ('10) is capable of being mounted on the camshaft assembly (50) to establish a driving connection between the outer tube (52) and inner shaft (54) of the camshaft assembly (50) and the respective members ('14a,'14b;'20) of the actuator ('10), after the camshaft assembly has been fitted to the engine, and an annular oil seal ('90) is mounted to the engine around the camshaft assembly (50) to engage slidably with a surface of the actuator ('10) to retain oil within a compartment of the engine housing the camshaft assembly.

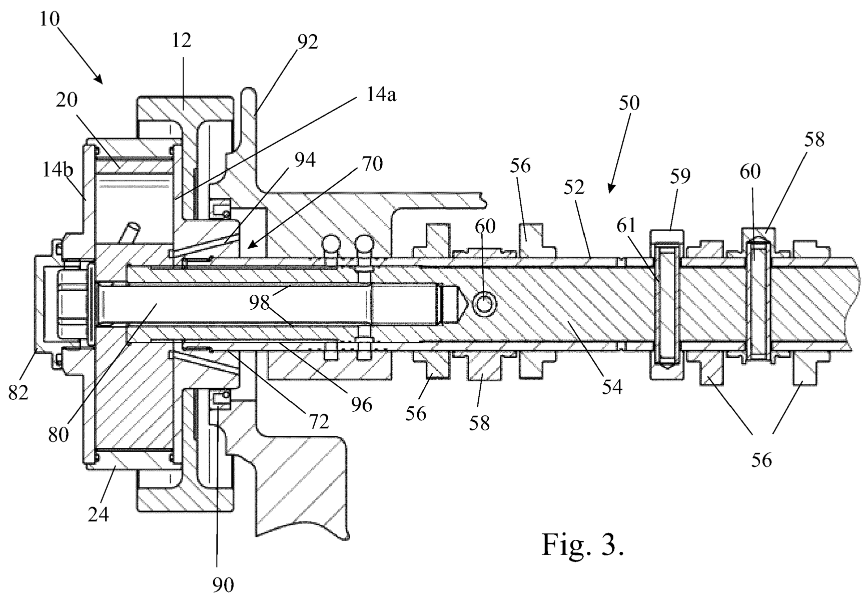

Fig. 3.

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Description

Field

[0001] The present invention relates to an engine having an assembled camshaft and an actuator, sometimes also termed a phaser, for varying the phase of at least some of the cam lobes of the camshaft relative to the crankshaft.

Background

[0002] An adjustable assembled camshaft is known that comprises a camshaft tube with two groups of cam lobes mounted on its outer surface. The first group of cam lobes is permanently fixed to the tube for rotation with the tube, while the second group of cam lobes is free to rotate relative to the surface of the tube and is connected for rotation with a drive shaft passing through the bore of the tube, by means of connecting pins that pass through circumferentially elongated slots in the tube. This type of assembled camshaft, also known as a concentric camshaft, allows the timing of its two groups of cam lobes to be varied in relation to one another by relative rotation of the camshaft tube and the inner drive shaft.

[0003] It is also known to provide an actuator to adjust the relative timing of the two groups of cam lobes. Some known actuators are configured to control the timing of one group of cam lobes relative to the other group, the latter group having a fixed timing relative to the crankshaft. Actuators are also known that can control the timing of both groups of cam lobes independently relative to the crankshaft.

[0004] The present invention is particularly concerned with engines with variable valve timing that utilise a dry timing belt to connect a camshaft to the crankshaft.

Object of the invention

[0005] The aim of the present invention is to provide an engine in which an actuator is integrated into a timing belt pulley driving a concentric camshaft and in which the actuator is sealed to prevent any oil contamination of the belt by oil escaping from the actuator.

Summary of the invention

[0006] According to the present invention, there is provided an engine as hereinafter set forth in Claim 1 of the appended claims.

[0007] Preferred features of the invention are set forth in the dependent claims.

[0008] When using a sealed actuator, a seal generally needs to be fitted to the cylinder head once the camshaft is in place and then the actuator needs to be fitted to the camshaft. A permanent connection between the actuator and the camshaft cannot generally be used because it prevents access to fit and/or service the seal. The present invention provides a solution for fitting a sealed actuator to an adjustable camshaft assembly while maintaining access to the seal located behind the actuator.

[0009] The invention employs an actuator design for a concentric camshaft that is suitable for applications requiring the actuator to be fully oil tight. This is a requirement when the actuator is located on the outside of the main engine structure, as is often the case when the drive connection to the crankshaft utilises a dry timing belt.

[0010] The actuator of the invention can be assembled to a concentric camshaft in a separate operation after the camshaft has been fitted to the engine or cylinder head and this provides access for the assembly and servicing of an annular seal, typically a lip seal, located concentrically with the camshaft and fitted to a stationary part of the engine behind the actuator. Once the seal is in place the actuator can be fitted to the concentric camshaft and connected to drive both groups of cam lobes on the camshaft.

[0011] Embodiments of the invention provide means for connecting the actuator to drive the camshaft which are applicable to both electric and hydraulic types of actuator. Some embodiments demonstrate the application of the invention to single actuators, where one group of cam lobes is driven in synchronism with the crankshaft and the actuator controls the phasing of the second group of cam lobes. Other embodiments demonstrate the application of the invention to twin actuators, which control the phasing of both groups of cam lobes relative to the crankshaft.

[0012] In the case of a hydraulic actuator, the requirement for total sealing is not generally compatible with an oil control valve mounted directly in the actuator, so the embodiments of the invention also show how hydraulic connections between the camshaft and the actuator can be provided. Furthermore, hydraulic actuators typically utilise a mechanical lock to set the relative angular orientations of the drive and driven members during startup when there is insufficient oil pressure to control the actuator effectively. The mechanical lock is conventionally released by oil pressure and requires a vent to ambient pressure in order to release effectively. Embodiments of the invention illustrate how a vent can be provided for the locking system by providing a connection to the engine crankcase, thus avoiding any external oil leak path.

[0013] Any concentric camshaft requires the axial position of the inner drive shaft relative to the camshaft tube to be controlled. Embodiments of the invention demonstrate how the relative axial positions may be set via the driving connections to the camshaft tube and the inner drive shaft.

Brief description of the drawings

[0014] The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a first exploded view of a first embodiment of the invention,
Figure 2 is a second exploded view of the embodiment shown in Figure 1,
Figure 3 is a section through the embodiment of Figures 1 and 2,
Figure 4 is an exploded view of a second embodiment of the invention,
Figure 5 is a section through the embodiment of Figure 4,
Figure 6 is an exploded view of a third embodiment of the invention,
Figure 7 is a section through the embodiment of Figure 6,
Figure 8 is an exploded view of a fourth embodiment of the invention,
Figure 9 is a section through the embodiment of Figure 8,
Figure 10 is an exploded view of a fifth embodiment of the invention, and
Figure 11 is a section through the embodiment of Figure 10.

Detailed description of the drawings

First Embodiment

[0015] A first embodiment of the invention is shown in Figures 1 to 3. In this embodiment an actuator 10 has a pulley 12 for accepting drive from the crankshaft via a toothed belt, neither of which is shown. The pulley 12 is connected to a drive member comprising two end plates 14a and 14b, and three sealed vanes 16 via three threaded fasteners 18 as shown most clearly in Figure 2. The driven member of the actuator 10 is formed as a disc 20 with three arcuate cavities 22 through which the three vanes 16 of the drive member pass. Each vane 16 acts to divide its respective cavity 22 into two hydraulic working volumes that are supplied with hydraulic oil to change the relative angle of the drive and driven members. In order to prevent any external leakage between the faces of the driven member 20 and the end plates 14a, 14b of the drive member, an outer ring 24 encloses the driven member 20 and is sealed between the end plates 14a, 14b of the drive member by two sealing rings 26.

[0016] A lock pin 28 loaded by means of a spring 30 is installed in the driven member 20. The lock pin 28 serves to fix the relative angular positions of the drive and driven members by latching in a bore 32 located in the front end plate 14b of the drive member, as shown in Figure 2. In order to release the lock, oil pressure is applied to the end face of the lock pin 28 that is engaged into the bore and when the oil pressure exceeds the preload force of the spring 30, the lock pin slides fully into the driven member and the actuator is free to rotate. In order for the lock pin to function correctly it is essential for the cavity 34 containing the spring 30 to be vented, otherwise the lock pin 28 will be prevented from sliding into the bore 34 in the driven member by trapped air/oil.

[0017] The actuator 10 is mounted to a concentric camshaft, generally designated 50, in the manner shown in the sectional view of Figure 3. The camshaft 50 is formed of an outer tube 52 and concentric inner shaft 54. Two sets of cam lobes are mounted on the outer tube 52, multiple lobes of each set being shown in the section of Figure 3. The first set of cam lobes 56 is fixed for rotation with the outer tube 52, for example by heat shrinking. The second set of cam lobes 58 is free to rotate about the outer tube 52 and is connected for rotation with the inner shaft 54 by means of pins 60 that pass through circumferentially extending slots in the outer tube 52. Figure 3 also shows a timing wheel 59 connected for rotation with the inner shaft 54 by means of a pin 61.

[0018] The drive member 14a, 14b is connected for rotation with the outer tube 52 of the camshaft via a threaded connection 70, comprising a female thread in a bore in the rear end plate 14a that engages with a thread machined directly into the camshaft tube 52. Concentricity is maintained by a close fitting bore diameter 72 adjacent to the thread. The actuator 10 can be tightened on to the tube via a drive hex located on the front plate 14b of the drive member.

[0019] While the threaded connection has the advantage that a fully assembled actuator 10 can be assembled to the camshaft 50, it also has the disadvantage that the angular orientation of the actuator 10 relative to the camshaft 50 is undefined because the position of the threaded joint when the specified tightening torque has been reached cannot be accurately defined. To overcome this, the drive pulley 12 has elongated holes 13 for the threaded fastenings 18 securing it to the drive member 14a, 14b so that the timing of the camshaft relative to the crankshaft can be accurately set.

[0020] The camshaft timing may be set, in the same way as carried out conventionally, by providing reference features on the camshaft 50 and the crankshaft that can be positioned relative to the engine structure by a pin or key to accurately set the respective orientations. The timing belt can then be fitted and tensioned, allowing the pulley 12 to take up its preferred angular position by rotating it relative to the rear plate 14a of the drive member. Finally the three actuator fastenings 18 can be tightened to secure the pulley 12 in the correct angular position.

[0021] The driven member 20 is connected for rotation with the inner shaft 54 of the camshaft by means of a clamping bolt 80. A sealing cover 82 is fitted to the front plate 14b to prevent any oil leakage once this clamping bolt 80 has been fitted.

[0022] In the embodiment of Figure 1, the orientation of the driven member 20 relative to the inner shaft 54 is not defined due to the threaded connection to the tube, so it is not possible to use a drive pin or key to set the angular position of the driven member 20 to the inner drive shaft 54. Torque is transmitted to the inner shaft by the friction induced by the clamping bolt 80. If necessary the torque capacity can be increased by adding a high friction washer or surface coating.

[0023] A rotary oil seal 90 is fitted to the engine cylinder head, part of which is shown in Figure 3 and designated 92. The oil seal 90 engages a cylindrical surface of the rear plate 14a of the drive member to prevent any oil leakage from inside the engine that could contaminate the timing belt. The rear plate 14a also has a hole 94 drilled through it, to allow the vent for the lock pin 28 to pass through the rotary seal 90.

[0024] The hydraulic connections for controlling the actuator 10 are shown in Figure 3 and comprise a first passage 96 located between the inner surface of the camshaft tube 52 and the outer surface of the inner shaft 54, and a second passage 98 located between the fixing bolt 80 securing the driven member 20 and an associated counter-bore in the inner shaft 54. A separate oil control valve can be connected to these oil feeds via the front journal bearing of the camshaft 50.

Second Embodiment

[0025] The second embodiment of the invention, shown in Figures 4 and 5, is generally similar to the first, but utilises a simpler actuator construction. To avoid repetition, in describing further embodiments of the invention identical components have been allocated the same reference numerals and modified components serving an analogous function have been allocated reference numerals with the same last two significant digits.

[0026] In the second embodiment, the drive member is a toothed belt pulley 112 that is clamped between two end plates 114a and 114b by means of four threaded fasteners 118. As with the first embodiment, the drive member is connected to the camshaft tube 52 via a threaded connection 70, such that the actuator 110 is assembled as a unit onto the front of the camshaft 50 but its angular orientation with respect to the camshaft is not defined due to the threaded connection.

[0027] In this embodiment the end of the camshaft tube 52 is not itself threaded, and instead a threaded drive adaptor 103 is permanently fitted to the end of the outer tube 52 by shrink fitting or a similar method. The drive adaptor also provides a location for a ball bearing 105 to provide radial support and axial location of the camshaft 50 in the engine as well as a concentric location diameter for the drive member 114a.

[0028] As with the first embodiment, a rotary oil seal 190 is located around the camshaft 50, and this seal can be fitted once the camshaft is in place, but before the actuator 110 is fitted. The actuator 110 can then be fitted to the end of the camshaft 50 and tightened using a drive hex on the front plate 114b, or other features on the drive member. After tightening the actuator 110 in position, the angular orientation of the toothed belt pulley relative to the camshaft can be adjusted to set the camshaft timing correctly and then clamped in position by the four threaded fastenings 118.

[0029] Once the pulley 112 is clamped, the central fixing bolt 80 connecting the driven member 120 of the actuator to the inner shaft 54 of the camshaft 50 is tightened, the drive torque capacity being enhanced in this case by a high friction washer. Finally, the sealing cap 82 is fitted to enclose the central bolt 80 and prevent oil leakage from the front of the actuator 110.

[0030] The second embodiment also shows a method for incorporating a bias spring 107 into the actuator 110. The bias spring 107 applies a torque between the drive member and the driven member to act against the mean drive torque of the inner shaft. This can be used to balance the actuator phasing response in both directions, or to bias the actuator towards its locked position when there is insufficient oil pressure to control the actuator effectively.

Third Embodiment

[0031] The third embodiment of the invention, shown in Figures 6 and 7, uses a hollow threaded fastener 213 to secure the actuator 210 to the camshaft tube 52, instead of having a direct threaded connection to the camshaft tube 52. This allows the actuator to be fitted in a defined angular orientation.

[0032] As with the second embodiment, a threaded drive adaptor 203 is permanently fitted to the end of the outer tube 52 by shrink fitting or a similar method. In the third embodiment however, the drive adaptor 203 has a location diameter with a key slot 205 so that the rear plate 214a of the actuator can be positioned concentrically and at the required angular orientation. The actuator plate 214a is then secured to the camshaft by tightening the hollow fastener 213 surrounding the inner shaft 54. Once the rear plate 214a has been secured to the camshaft 50, the rest of the actuator 210 can be secured using four smaller threaded fasteners 218 and the driven member 220 can then be secured to the inner shaft of the camshaft using the centre bolt 280.

[0033] The third embodiment also illustrates an alternative configuration for the hydraulic connections for controlling the actuator 210. In this embodiment, a first oil passage 298 is located between the inner surface of the camshaft tube 52 and the outer surface of the inner shaft 54, and passes through the bore of the hollow fastener 213. The second oil passage 296 passes into the inner shaft 54 and through a hole in the centre fixing bolt 280 securing the driven member 220 to the inner shaft 54. As before, these oil feeds are connected to an oil control valve via the front journal bearing of the camshaft.

[0034] Once again, the drive pulley 212 has elongated fixing holes to allow the camshaft timing to be set accurately, but the actuator 210 of the third embodiment could also have a drive pulley fitted in a fixed orientation or combined with another part of the drive member because its orientation relative to the camshaft is defined by the timing key.

[0035] As an alternative to the hollow fastener 213, it would be possible to extend the camshaft drive adaptor 203 through the rear plate 214a of the actuator 210 and provide an externally threaded portion. The rear plate 214a of the actuator could then be secured in position using a nut.

[0036] The advantage of the third embodiment is that it allows the actuator 210 to be assembled to the camshaft 50 in a defined angular orientation. Its main disadvantage is that the actuator 210 cannot be fitted as a single unit because the rear plate 214a needs to be fitted and the hollow fastener 213 tightened before the rest of the actuator 210 is fitted.

Fourth Embodiment

[0037] The fourth embodiment of the invention, shown in Figures 8 and 9, illustrates how the invention can be applied to a double actuator, also known as a twin phaser, in order to control the timing of each of the two groups of cam lobes independently relative to the crankshaft. In this case the actuator 310 has a drive member 312 connected for rotation in synchronism with the crankshaft and two driven members 320a and 320b, the first being connected for rotation with the camshaft outer tube 52, the second connected for rotation with the inner shaft 54.

[0038] As with the second and third embodiments, a threaded drive adaptor 303 is permanently fitted to the end of the outer tube 52 by shrink fitting or a similar method. The actuator 310 is designed to be assembled to the camshaft in two parts, the first comprising the drive pulley 312, rear closing plate 314a and a first rotor 320a and stator 321a, the second comprising a separator plate 314c, the second rotor 320b and stator 321b, and the front closing plate 314b.

[0039] The first part of the actuator is assembled by sliding the rear closing plate 314a on to the camshaft drive adaptor 303, engaging its outer surface with the rotary seal 390 fitted to the cylinder head 392. Then, then the first driven member 320a of the actuator is secured to the drive adaptor 303 by a hollow fastener 313, the correct angular orientation being defined via a timing key. The second part of the actuator 310 can then be fitted to the first, and secured by a group of five threaded fasteners 318, before the centre bolt 380 is tightened to secure the second driven member 320b to the inner shaft 54 of the camshaft. Finally the sealing cap 382 can be fitted over the centre bolt 380 to seal the actuator oil supply.

[0040] As with the previous embodiments the angle of the drive pulley is adjustable to allow accurate setting of the camshaft timing the drive pulley being secured in position by the five fasteners 318 securing the two parts of the actuator together.

[0041] The fourth embodiment also illustrates how the hydraulic connections for controlling the double actuator can be provided from the outer surface of the camshaft drive adaptor 303. A first oil passage is defined between the inner surface of the drive adaptor 303 and the outer surface of the hollow fastener 313, a second passage between the inner surface of the fastener 313 and the outer surface of the inner shaft 54, a third passage between the bore of the inner shaft 54 and the outer surface of the centre bolt 380 and a fourth passage through the centre of the bolt 380. Seals are also provided on the outside of the inner shaft 54 in order to separate the oil flow paths.

Fifth Embodiment

[0042] The fifth embodiment of the invention, shown in Figures 10 and 11, utilises a separate mounting flange 531 that engages with a splined or form fit connection on the drive adaptor 503 of the camshaft 50 and is retained by a hollow fastener 513 in order to mount the actuator 510. In this case, the mounting flange 531 engages into the rotary seal 590 mounted into the cylinder head and a seal 533 is used to prevent any oil leakage between the actuator 510 and the mounting flange 531. This arrangement allows the actuator 510 to be assembled to the camshaft 50 as a single unit whilst still allowing oil to be supplied to the actuator 510 via its connection to the camshaft 50 and providing a vent passage for any waste oil to be returned to the engine crankcase through the central opening of the rotary seal via clearance cavities in the splined connection in the splined connection to the drive adaptor 503.

[0043] In this case an electric actuator 510 has been combined with the concentric camshaft 50, but a similar mounting arrangement could alternatively be applied to a hydraulic actuator. The stator of the electric actuator 510 is secured to the flange 531 mounted on the camshaft 50 by four threaded fasteners 518 and the rotor 520 of the actuator 510 is engaged by a spline or form fit connection to the inner shaft 54 of the camshaft, and is axially retained via a central bolt 580.

[0044] The actuator 510 is engaged via a drive coupling with an electric motor 521 mounted by fastenings 517 to a stationary part 519 of the engine. The rotational speed of the motor 521 is variable relative to the camshaft rotational speed in order to advance or retard the timing of the inner shaft 54 relative to the outer tube 52 of the camshaft 50. A second rotary seal 541 mounted to the electric motor 521 engages with a cylindrical surface 543 on the actuator 510 to enclose the drive coupling such that it can be lubricated during operation without any oil contamination of the timing belt.

[0045] The use of an additional rotary seal on the opposite side of the actuator to the camshaft can also be used in conjunction with a hydraulic actuator design having an integrated spool valve (as illustrated in EP application EP17168117.4) to enclose the hydraulic spool valve and the solenoid plunger. It would be possible to mount the seal to either the cylinder head, the actuator end plate or the solenoid.

Advantages of embodiments of the invention

[0046] The proposed invention has the following advantages when compared to existing designs: -

- The actuator of the invention can be used for concentric camshaft applications where 100% oil sealing is required.
- Access is provided to a rotary oil seal located concentrically to the camshaft behind the actuator.
- The design is applicable to both hydraulic and electric actuators.
- The design can be adapted for both single and double actuator applications
- The actuator drive connections can be used to define hydraulic connections between the actuator and the concentric camshaft.
- The actuator is able to control the axial location of the inner drive shaft inside the camshaft tube.
- The invention is compatible with a variety of common procedures for setting the camshaft timing.

Claims

1. An engine having an adjustable camshaft assembly (50) having first (56) and second (58) groups of cam lobes and an actuator ('10) for varying the phase of at least one of the groups of cam lobes (56,58) relative to a crankshaft of the engine, wherein
the camshaft assembly (50) comprises an inner shaft (54) and an outer tube (52) surrounding and rotatable relative to the inner shaft (54), the first group of cam lobes (56) being fixed for rotation with the outer tube (52) and the second group (58) being rotatably mounted on the outer tube (52) and connected for rotation with the inner shaft (54) by means of connecting members (60) passing through circumferentially extending slots in the outer tube (52), and
the actuator ('10) comprises a drive member ('14a, '14b) and one or more driven members ('20) that are rotatable relative to the drive member, the groups of cam lobes of the adjustable camshaft assembly each being connected for rotation with a respective one of the drive member and the driven member(s) of the actuator,
characterised in that
the actuator ('10) is capable of being mounted on the camshaft assembly (50) to establish a driving connection between the outer tube (52) and inner shaft (54) of the camshaft assembly (50) and the respective members ('14a, '14b; '20) of the actuator ('10), after the camshaft assembly has been fitted to the engine, and
an annular oil seal ('90) is mounted to the engine around the camshaft assembly (50) to engage slidably with a surface of the actuator ('10) to retain oil within a compartment of the engine housing the camshaft assembly.

2. An engine as claimed in Claim 1, wherein the member of the actuator serving to drive the outer tube of the adjustable camshaft is connected thereto via a single threaded connection, the axis of the thread being substantially coaxial with the camshaft axis.

3. An engine as claimed in Claim 2, wherein the actuator has a direct threaded connection to the camshaft tube, or to a component fixably connected to the camshaft tube, such that the angular orientation of the actuator relative to the camshaft tube after assembly is undefined.

4. An engine as claimed in Claim 1 or Claim 2 wherein the actuator is connected to the camshaft tube in a defined orientation, a separate threaded component being provided to secure the actuator to the camshaft tube, or a component fixably connected to the camshaft tube wherein the threaded component has a bore substantially concentric to the camshaft axis to allow access for the drive connection between the actuator and the inner drive shaft.

5. An engine as claimed in any one of Claims 1 to 4, wherein the member of the actuator serving to drive the inner shaft of the adjustable camshaft is connected thereto via a single threaded connection, the axis of the thread being substantially coaxial with the camshaft axis.

6. An engine as claimed in any one of Claims 1 to 5, wherein the actuator is fitted with a toothed pulley or gear to be driven by the crankshaft, wherein the angular position of the pulley relative to the actuator is adjustable to allow the camshaft timing relative to the crankshaft to be set accurately.

7. An engine as claimed in any one of claims 1 to 6, wherein the actuator is hydraulically operated and two or more separate hydraulic oil connections are provided between the actuator and the adjustable camshaft in order to control the angular position of one or more driven members relative to the drive member.

8. An engine as claimed in claim 7 when appended to claim 4, wherein one or more hydraulic oil paths are defined by the threaded component.

9. An engine as claimed in claim 7 or 8, wherein the actuator has a hydraulically released locking mechanism to define the angular position of one or more driven members relative to the drive member during start-up or low oil pressure supply conditions, wherein a vent passage is provided for the locking mechanism, the vent passage being located radially inwards of the annular oil seal and in communication with the compartment of the engine housing the camshaft assembly.

10. An engine as claimed in any one of Claims 1 to 6, wherein the actuator is electrically operated and an oil connection is provided between the adjustable camshaft and the actuator in order to lubricate the actuator.

11. An engine as claimed in any one of claims 1 to 10, wherein the actuator is a twin actuator having one drive member and two driven members wherein each of the driven members is connected for rotation with a respective one of the groups of cam lobes, to enable the angular position of each driven member to be adjusted independently relative to the drive member.

12. An engine as claimed in any one of claims 1 to 11, wherein the surface of the actuator in sealing sliding contact with the annular seal is a cylindrical surface formed by a separate mounting component that is secured to the camshaft outer tube, the actuator being secured to the mounting component via one or more threaded fasteners, a sealed connection being formed between the actuator and the mounting component to prevent oil leakage.

13. An actuator as claimed in any one of claims 1 to 12, wherein the driving connection between the actuator and at least one of the outer tube (52) and the inner shaft (54) of the camshaft assembly (50) includes a spline or form fit connection capable of transmitting the driving torque.

14. An actuator as claimed in claim 13, wherein a threaded fastener coaxial to the axis of the spline or form fit connection is utilised to set the axial position of the outer tube (52) in relation to the inner shaft (54).

15. An actuator as claimed in any of claims 1 to 14, wherein the actuator is operated by a control system mounted to a stationary part of the engine and comprising a hydraulic valve actuator or an electric motor located adjacent to the opposite side of the actuator from the camshaft, and wherein an annular oil seal is provided to retain oil inside the actuator and the control system.

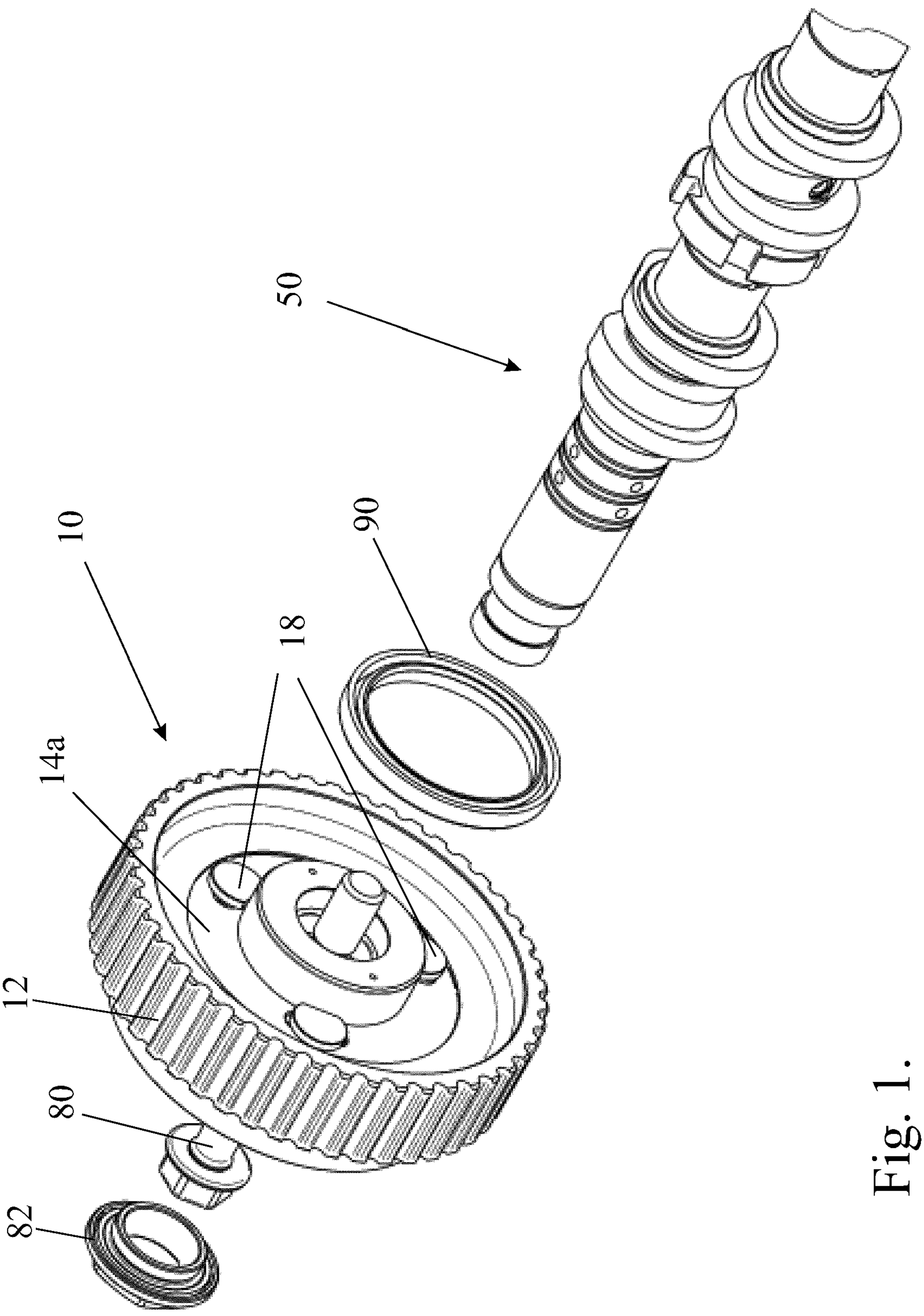

Fig. 1.

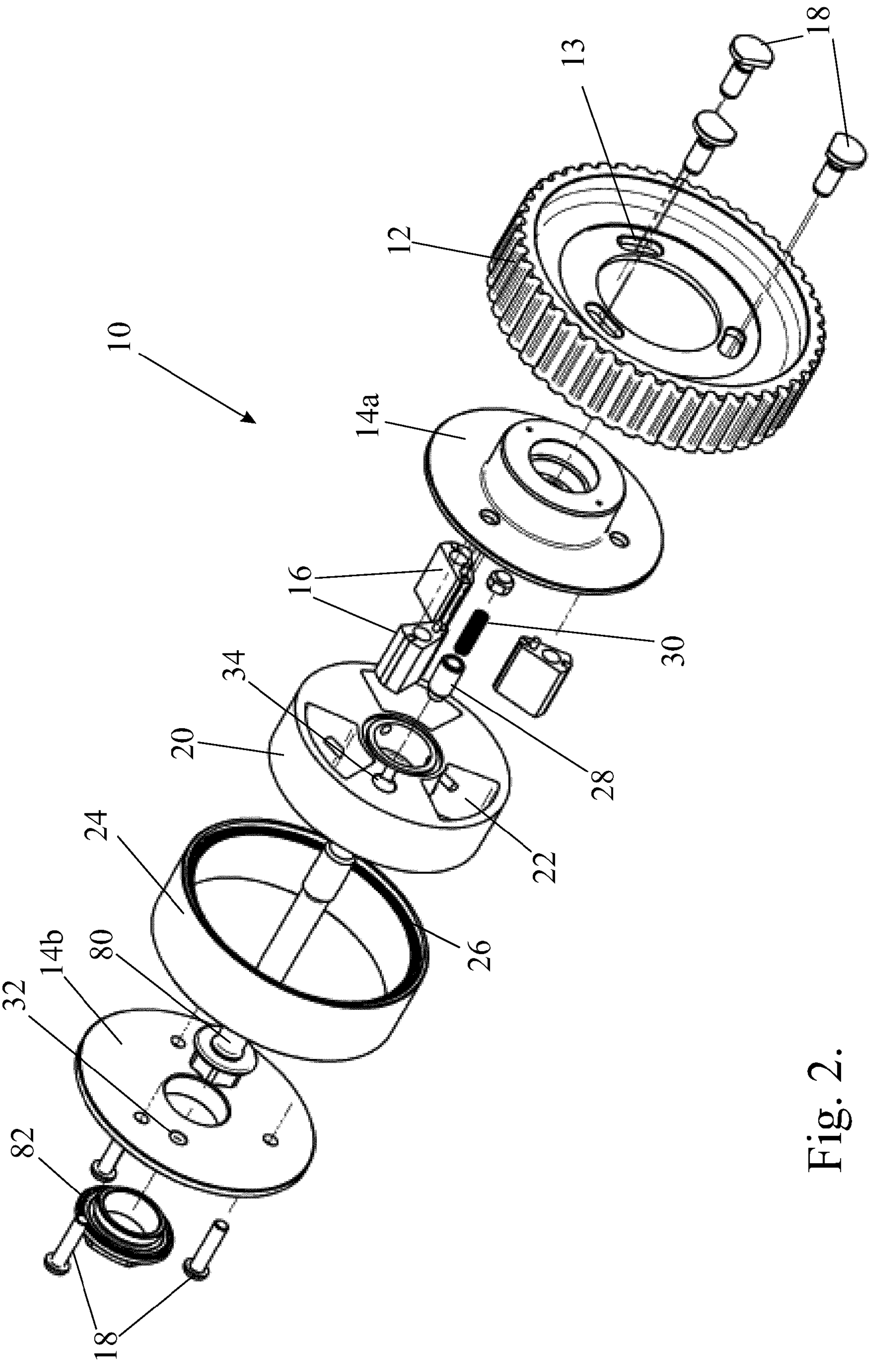

Fig. 2.

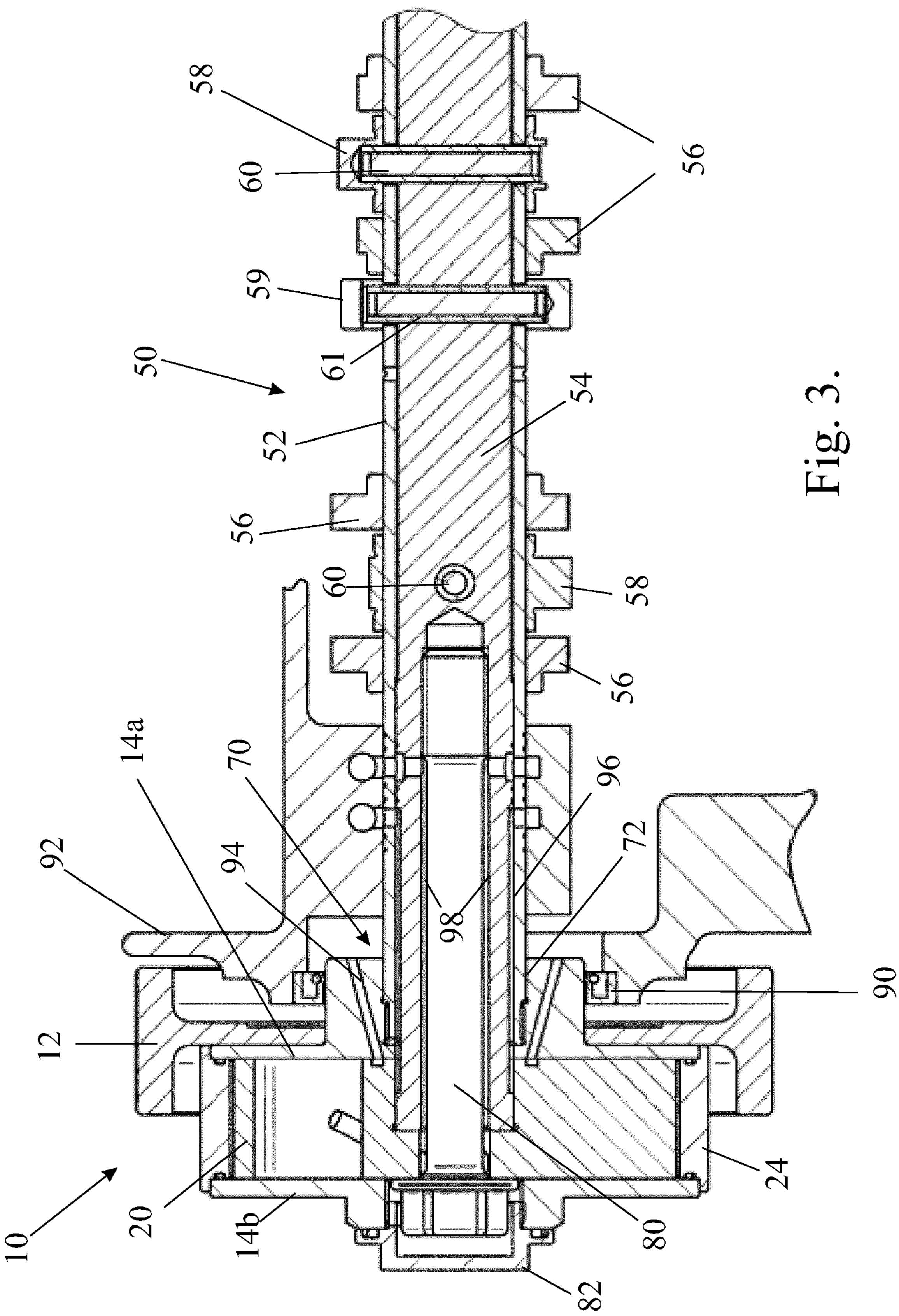
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Fig. 3.

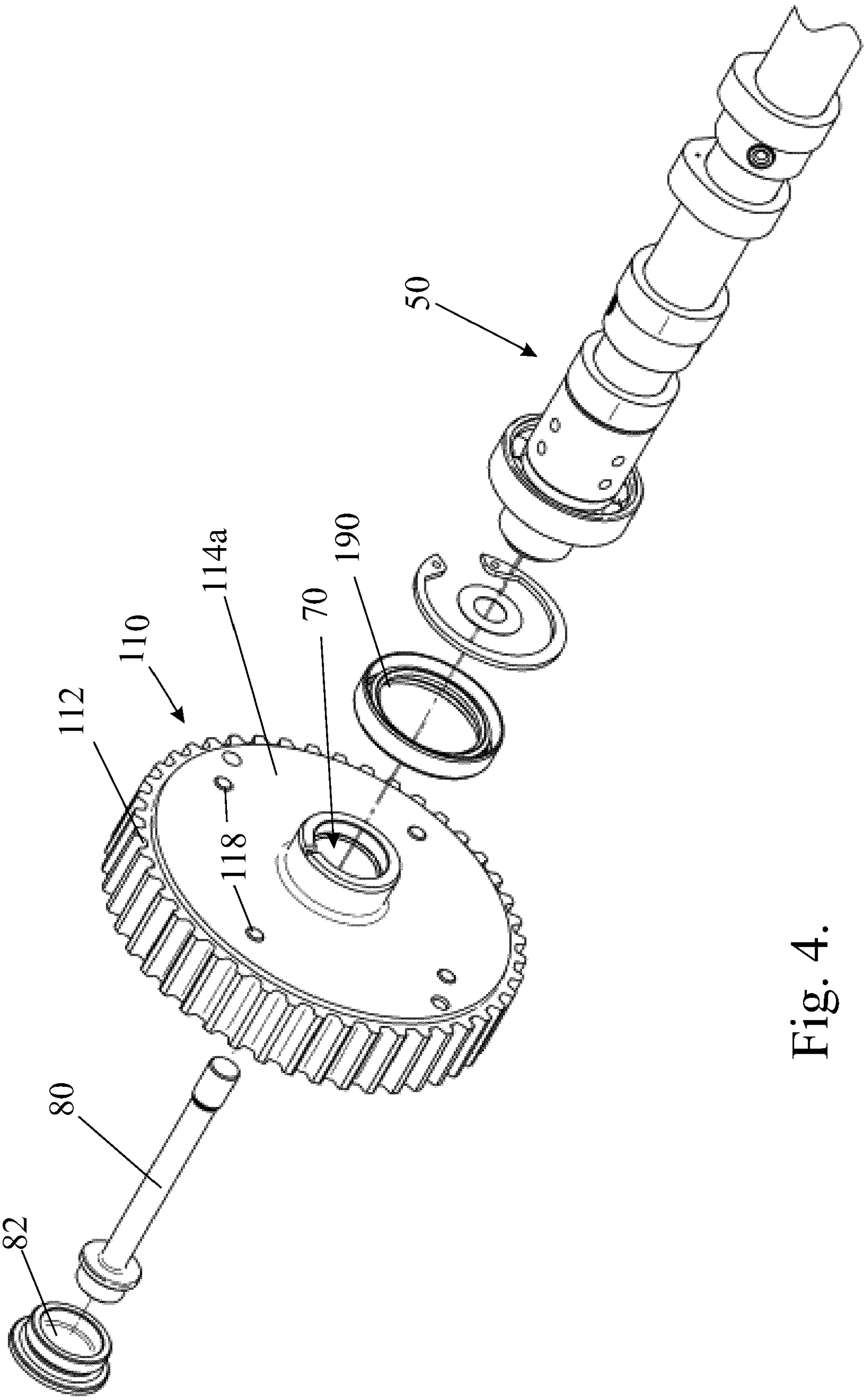

Fig. 4.

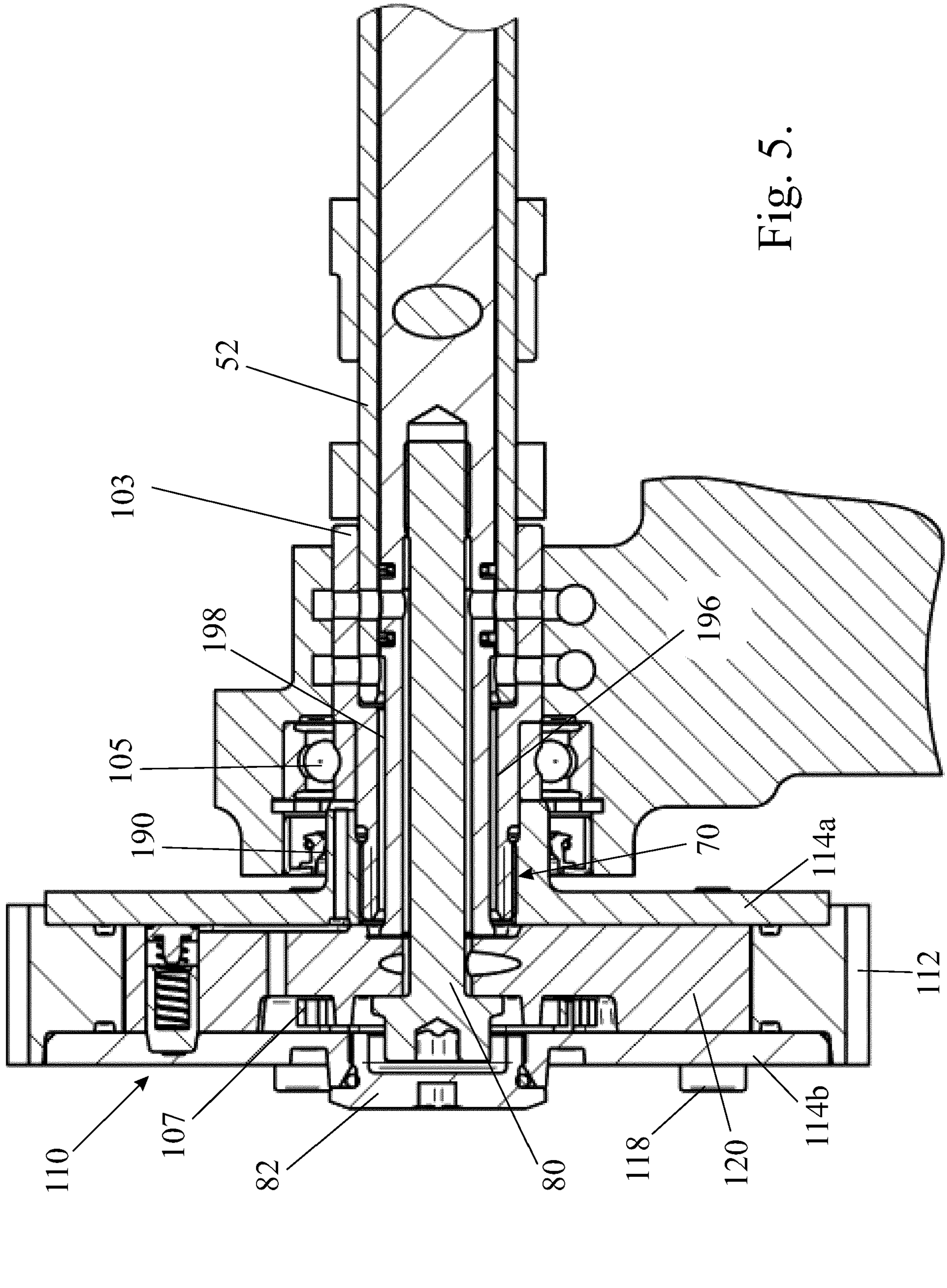

Fig. 5.

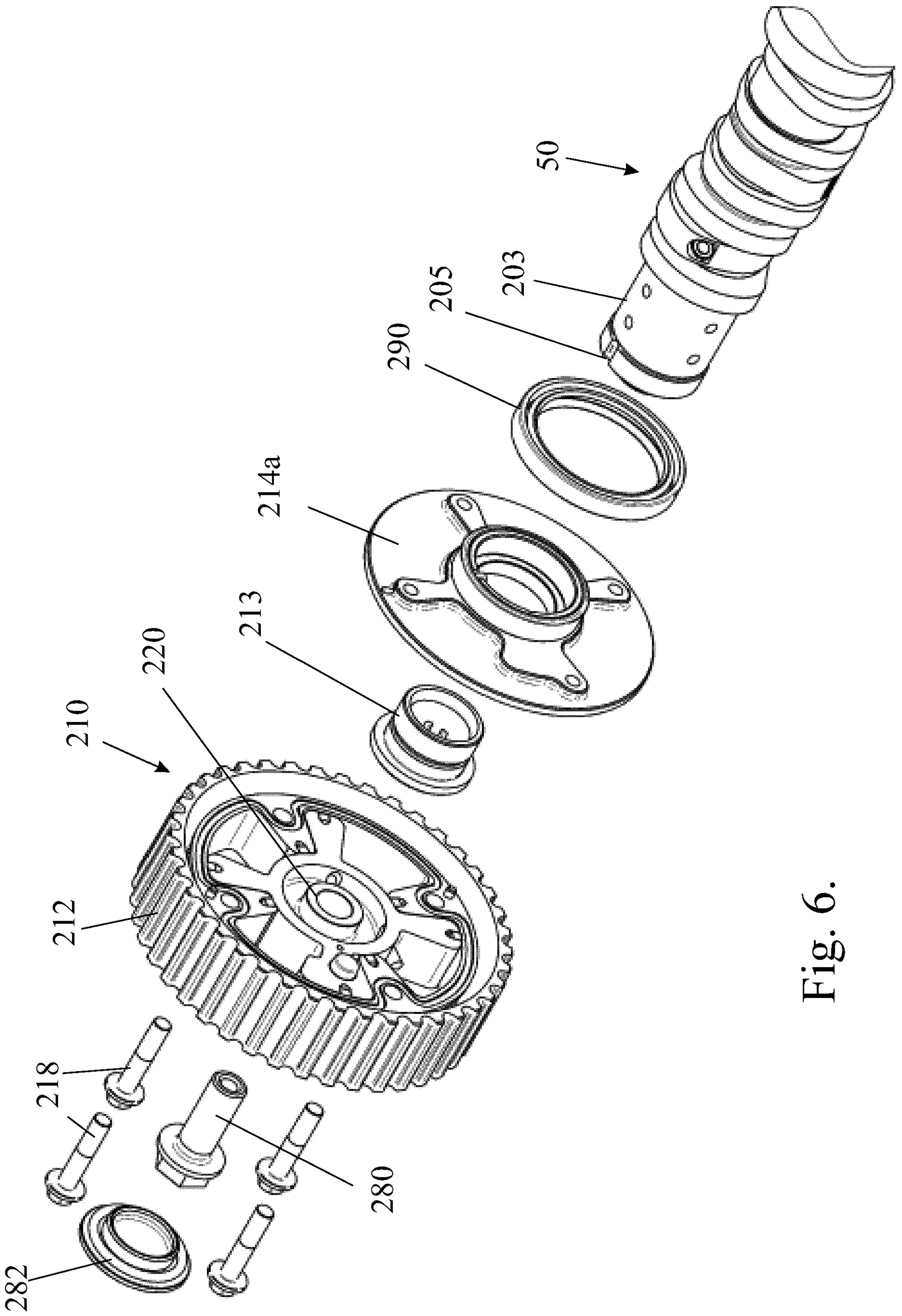

Fig. 6.

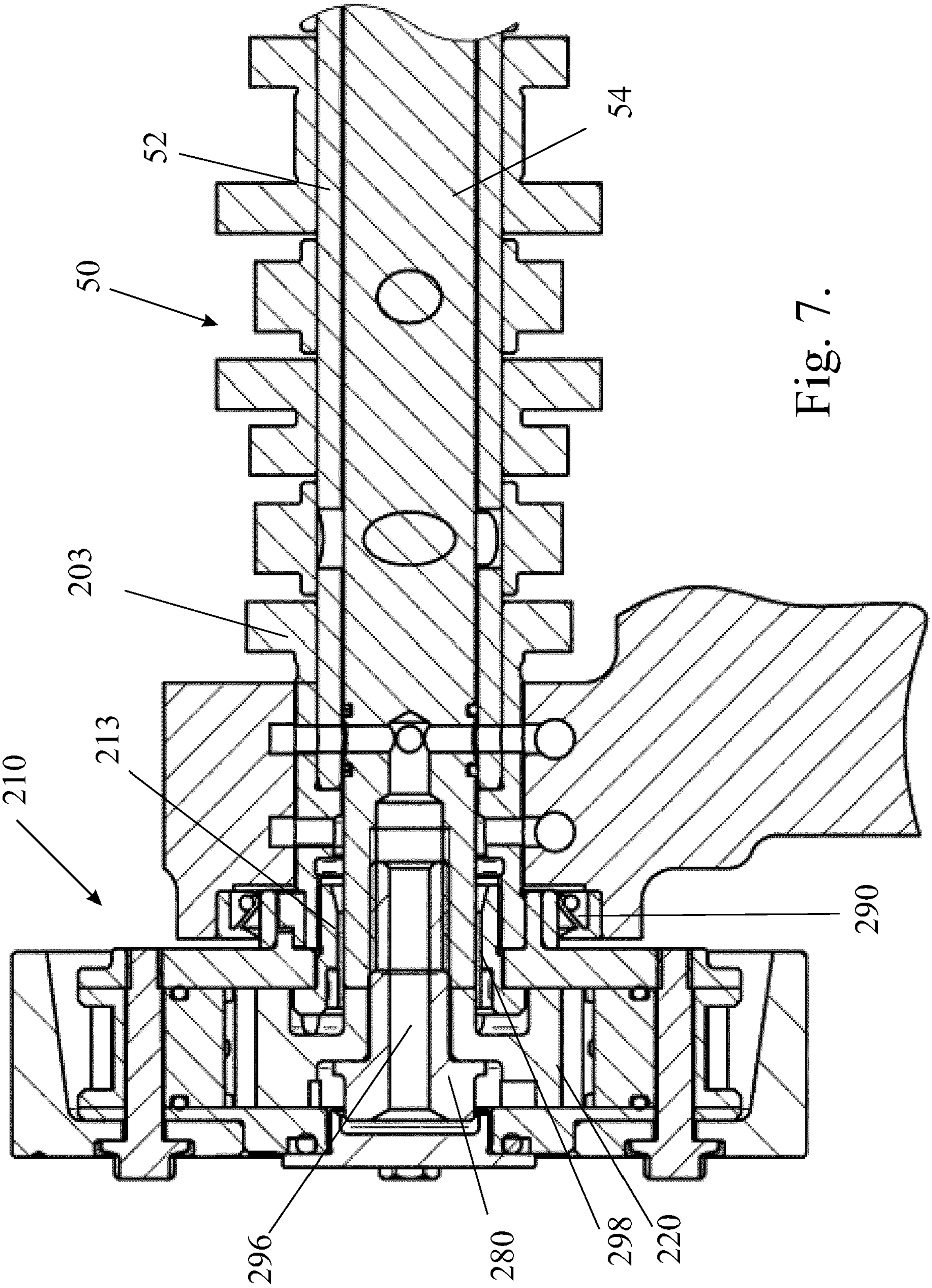

Fig. 7.

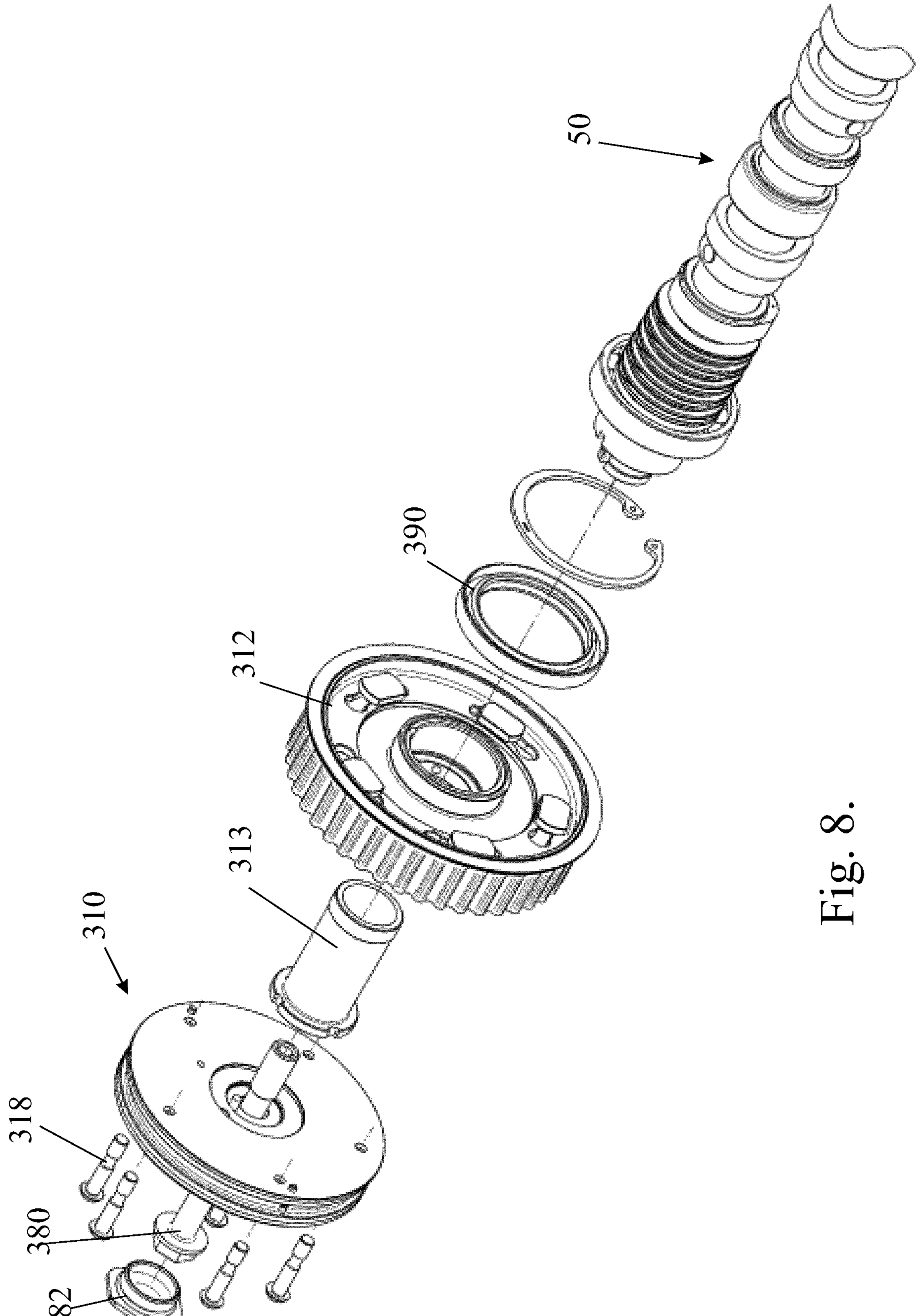

Fig. 8.

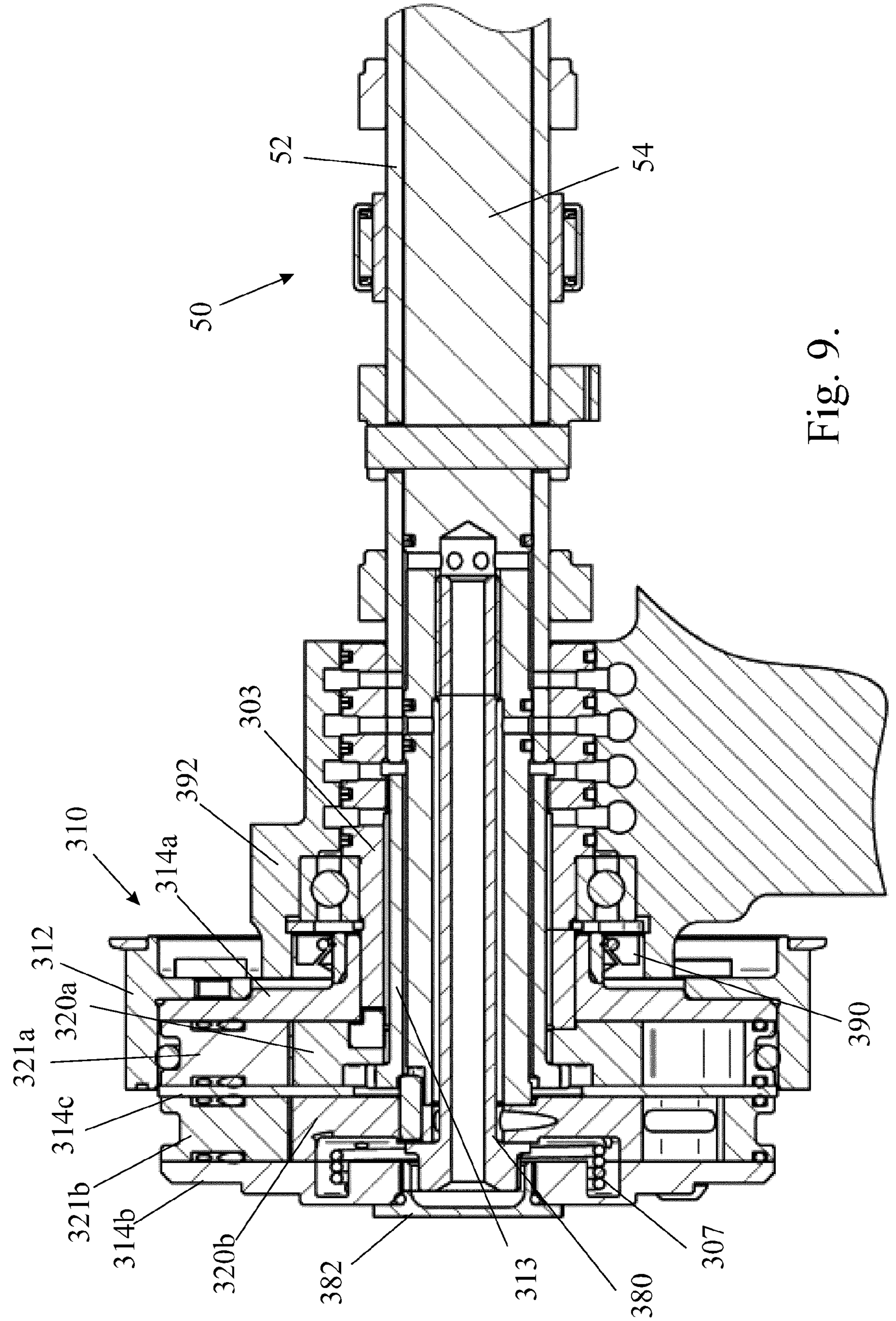
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Fig. 9.

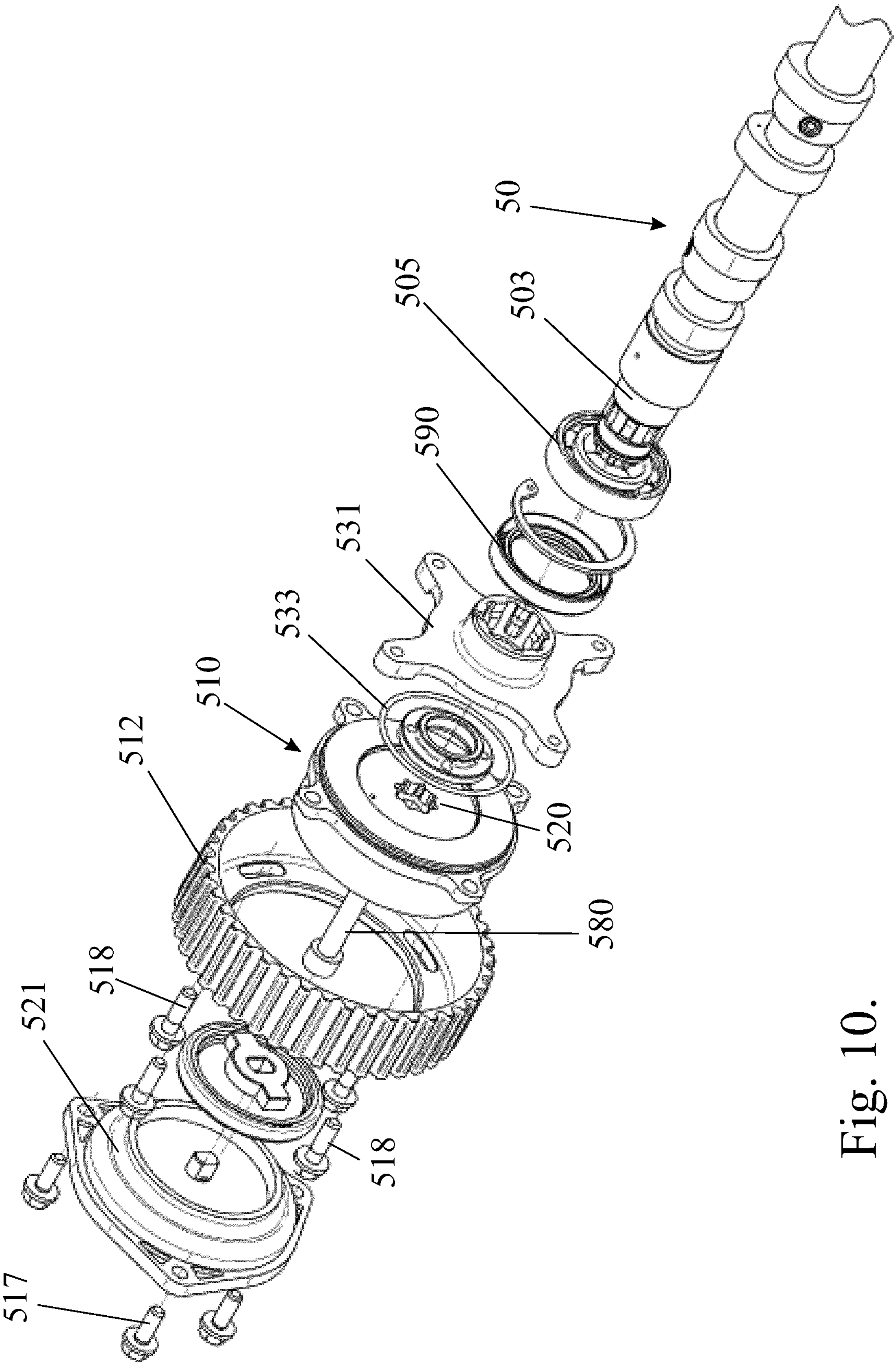

Fig. 10.

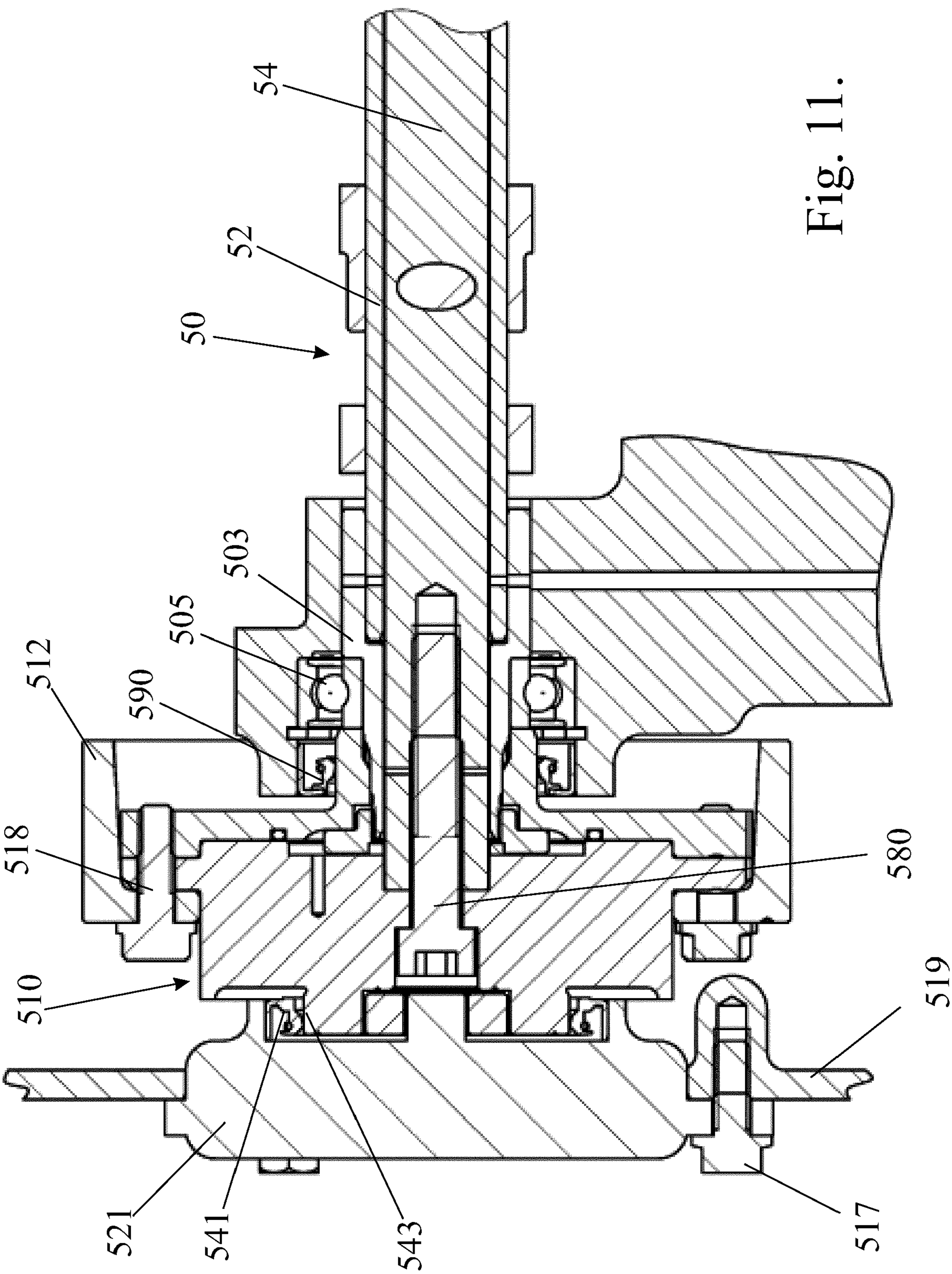

Fig. 11.

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EUROPEAN SEARCH REPORT

Application Number
EP 17 19 5055

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	14 March 2018	Aubry, Yann

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14-03-2018

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