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(71) Applicant: **Mechadyne International Ltd.**
**Kirtlington**
**Oxfordshire OX5 3JQ (GB)**

(72) Inventors:
- **Fernandez-Oxby, Owen**
  **Bletchley, MK3 5DR (GB)**
- **Lees, Robert**
  **Daventry, NN11 6UF (GB)**
- **Walton, Mark**
  **Brackley, NN13 6FS (GB)**

(74) Representative: **Harrison IP Limited**
**3 Ebor House**
**Millfield Lane**
**Nether Poppleton, York YO26 6QY (GB)**

(54) **MECHANICAL LOCKING PIN ASSEMBLY**

(57) There is provided a mechanical locking pin assembly comprising a hollow cylindrical locking pin retractable into the through bore and having an extended position protruding from the member, a spring seat for mounting within the through bore to grip the inner wall of the through bore, and a spring disposed within the locking pin and acting on the spring seat to urge the locking pin away from the spring seat toward the extended position. The spring seat comprises an end plate and plurality of protrusions extending axially from the perimeter of the end plate toward the locking pin. Complimentary axially extending slots are formed in the cylindrical side wall of the locking pin for receiving the protrusions of the spring seat in both the extended and retracted positions of the locking pin. When used in a cam phaser, this proposal enables a phaser of a shorter overall length.

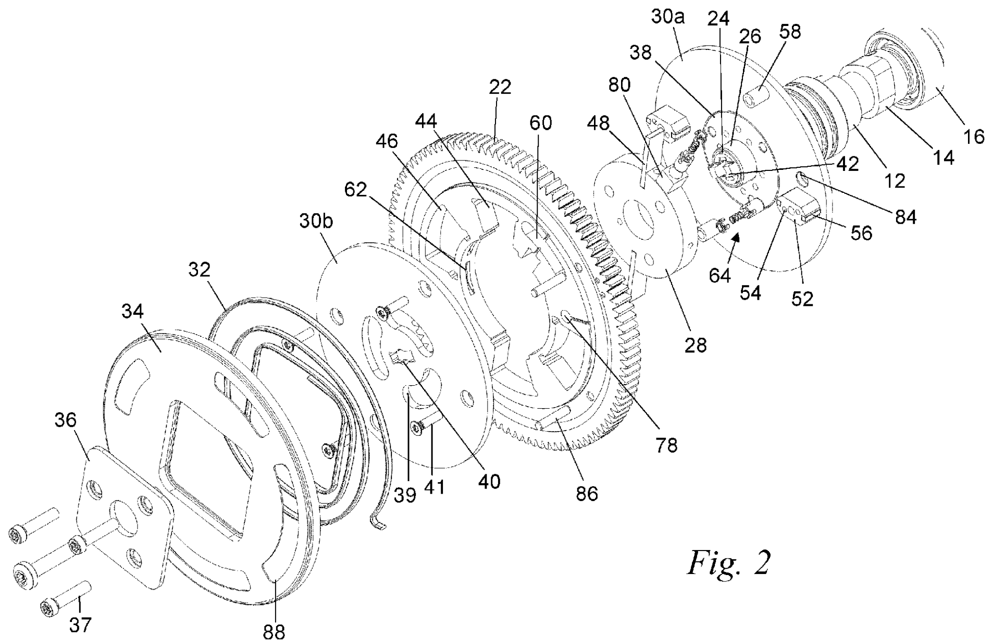


*Fig. 2*



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## Description

FIELD

**[0001]** The invention relates to a mechanical locking pin assembly which may be used, for example, in a camshaft phasing system.

BACKGROUND

**[0002]** Camshaft phasing systems are known to include locking systems, employing locking pins that act to ensure that the phased cam lobes remain in known positions when they are unable to be controlled by the phasing system during certain engine operating conditions, for example due to low engine oil pressures such as engine start-up/shut-down, or to act as a failsafe in case of component/software failure.

**[0003]** The minimum axial length of a hydraulic phasing system is physically limited by: a) the turning effort (torque) required of the phaser, as reducing the length of the phaser's hydraulic cavities reduces the area upon which the hydraulic fluid acts, reducing the torque output; and b) engagement lengths for mechanical features such as locking pins and threaded fasteners, which for a robust design require minimum engagement lengths; among other requirements.

OBJECT

**[0004]** The invention seeks to provide a mechanical locking pin assembly having a minimum axial length. Such a locking pin assembly is particularly useful, for example, in a heavy-duty internal combustion engine where axial length of the engine is limited as described below. However, the invention may find use in applications outside of such an engine.

SUMMARY

**[0005]** According to the present invention, there is provided a mechanical locking pin assembly as hereinafter set forth in Claim 1 of the appended claims.

**[0006]** Preferred features of the locking pin assembly are hereinafter set forth in claims 2 and 3 of the appended claims.

**[0007]** A phasing system comprising the locking pin assembly is hereinafter set forth in claims 4 to 8 of the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

**[0008]** The invention will now be described further, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is an isometric view of a concentric camshaft and a camshaft phasing system,

Figure 2 is an exploded view of the phasing system shown in figure 1,

Figure 3 is a section through a stator of a first embodiment of the phasing system,

Figure 4 is a section through a stator of a second embodiment of the phasing system,

Figure 5 is an exploded view of a locking pin,

Figures 6a and 6b are sections through the phaser, showing the locking pin, deployed axially with respect to the camshaft, in a locked and an unlocked configuration,

Figure 7 shows an exploded view of a stator and rotor having a locking pin deployed in a radial manner,

Figure 8 shows a second embodiment of the rotor, and

Figure 9 shows a spring and a spring holder mounted to the stator.

DETAILED DESCRIPTION OF THE INVENTION

**[0009]** Figure 1 shows a dual independent camshaft phasing system 18 for use in a gear driven, cam-in-block internal combustion engine. The system 18 is mated to a concentric camshaft 10 having two groups of cam lobes 12, 14, mounted respectively for rotation with the outer tube and the inner shaft of the concentric camshaft 10, and bearings 16 to allow the camshaft to rotate in the engine. The bearings 16 may be rigidly mounted to the outer tube of the camshaft 10. The phasing system 18 serves to control the phase of the first and second group of cam lobes 12, 14 independently in relation to the crankshaft (not shown).

**[0010]** The camshaft 10 may further comprise a target wheel 20 for a sensor, the sensor being mounted to the engine (not shown). The sensor and target wheel serve to detect the phase angle of the cam lobes relative to a part of the engine which is coupled to the crankshaft, such as a camshaft drive gear 22. In embodiments of the invention described below, the camshaft drive gear 22 serves as the stator of the phasing system.

**[0011]** The axial ends of inner shaft 24 and the outer tube 26 of the camshaft 10 are shown in Figure 2. The phasing system 18 comprises an annular stator 22, a first phaser output member 28 in the form of a hub concentrically positioned with the stator 22, a second phaser 30 output member comprising two end plates 30a, 30b axially straddling the stator 22, a spiral spring 32, a spring cover 34, and an inner fixation 36. The spring 32, cover 34, and inner fixation 36 are optional as they are not required to change the phase of the cam lobes 12, 14. Their purpose and construction will be described below in relation to figure 9.

**[0012]** The first phaser output member 28 is configured for rotation with the outer tube 26, and therefore the first group of cam lobes 12, by mounting its inner circumference directly to the outer tube 26 and fastening the first phaser output member 28 to a bearing 38 at the drive end of the camshaft 10, the bearing 38 being rigidly mounted to, and rotatable with, the outer tube 26 and having threaded holes therein to enable it to be secured to the first phaser output member 28 by means of fasteners 37 passing through arcuate slots 39 in the end plate 30b.

**[0013]** The second phaser is connected for rotation with the inner shaft 24 by means of a slot 40 located in the second end plate 30b. The slot 40 is of a shape complimentary to protrusions 42 on the inner camshaft 24, so that any rotational movement of the second end plate 30b results in corresponding rotation of the inner camshaft 24. The first end plate 30a and the second end plate 30b which sandwich the stator 22 between them and are connected to one another by fasteners 41.

**[0014]** As known in the art, the cam lobes 14 of the second group are connected to the inner camshaft 24 by means of pins passing through circumferential slots in the outer tube 26, and into the lobes 14, the latter being free to rotate about the outer tube 26.

**[0015]** The stator 22, as most clearly shown in figure 3, has a toothed outer circumference and is configured to be driven from the crankshaft by means of a gear train. The stator 22 comprises two sets of arcuate cavities 44, 46 each associated with a respective one of the output members. The cavities 44 in Figure 3 interrupt the inner circumference of the stator 22, and receive vanes 48 connected to the output member 28 of the first phaser. On the other hand, the cavities 46 do not interrupt the inner circumference of the stator and they receive vanes 52 fastened to the plates 30a and 30b that together act as the output member of the second phaser.

**[0016]** The stator 22 is mounted to the outer diameter of the first phaser output member 28. As the output member 28 is mounted directly onto the outer tube 26, and the stator 22 is mounted to the outer diameter of the first phaser output member 28, the stator is thereby accurately positioned having its drive gear mounted concentrically to the camshaft 10. This is crucial to maximise component durability and reduce the running noise of the drive gear in operation. The accurate location of the stator 22 is more important in engines utilising gear-driven cams because there is no flexible element, such as a belt or chain, to accommodate any minor misalignment.

**[0017]** The number of cavities 44, 46 and their positions relative to each other are chosen such that the area of contact (the bearing area) between the inner circumference of the stator 22 and the outer circumference of the first phaser output member 28 is maximised. Maximising the bearing area helps to position the stator 22 accurately during assembly of the engine, and also reduces wear due to less pressure at the interface.

**[0018]** The first cam phaser output member 28 features radial slots extending inwards from its outer circumference. These slots allow the first phaser output member 28 to make use of vanes 48 which extend into the cavities 44 and act as a sealing wall, splitting each cavity 44 into two sections. As such, there will be as many slots and vanes 48 as there are cavities 44 for the first phaser output member 28. When hydraulic pressure is increased on one side of the vane 48, it will cause the vanes 48 to move within the cavities 44, thereby causing the phaser output member 28 to rotate. This ultimately leads to the first group of cam lobes 12 changing phase. The vanes 48 may be radially sprung such that the vane tips remain in light contact with the outer extremities of their cavities 44, thereby providing a suitable hydraulic seal.

**[0019]** Oil passageways 50 are formed from axial and radial drillings in the first phaser output member 28 and serve to direct pressurised oil from oil control valves, located elsewhere in the engine, through the phaser output member 28 and to the hydraulic cavities 44, 46 of the first and second phasers 28, 30 as required by a control module (such as an ECU) of the engine.

**[0020]** The second cam phaser, as earlier mentioned, has a different construction from the first in order to maximise the aforementioned bearing area. The two end plates 30a, 30b are positioned either side of the stator 22 and are fastened together. Fastenings 41 may, for example, locate in threaded holes of vanes 52. The cavities 46 associated with the second phaser 30 do not interrupt the internal circumference of the stator 22 and are instead radially and circumferentially enclosed by the stator 22. The first end plate 30a of the second phaser 30 includes vanes 52. The vanes 52 may be located on the face of the first end plate 30a by dowel pins 54, or alternatively formed as part of the end plate 30a. The vanes 52 associated with the second group of cavities 46 serve a similar purpose to the vanes 48 associated with the first group of cavities 44 in that they split each cavity 46 into two working chambers. The vanes 52 may comprise sprung sealing elements 56 to seal the cavity 46.

**[0021]** The inner circumference of the stator 22 features circumferential slots 62 so that hydraulic fluid can enter and exit the second group of cavities 46, and thereby control the phase of the second group of cam lobes 14, irrespective of the angular position of the first phaser output member 28 in relation to the stator 22.

**[0022]** The first end plate 30a of the second phaser 30 may further feature stiffening elements 58. The stiffening elements 58 may be fastened to the first end plate 30a in the same manner as the vanes 52 and serve to reduce the distance between fastenings holding the first and second end plates 30a, 30b together. The stiffening elements 58 have the same axial length as the vanes 52 and therefore together act to reduce the deflection of the end plates 30a, 30b when the system is under hydraulic pressure. Consequently, the level of leakage of hydraulic fluid is reduced. Further, the addition of stiffening elements 58 and fastenings reduces the stress placed on the fastenings located in the vanes 52. Arcuate slots 60 are provided within the stator 22 to allow clearance of the stiffening elements 58 throughout their range of motion.

**[0023]** An alternative embodiment of a phasing system is shown in figure 4. To avoid unnecessary repetition, components serving the same purpose as previously described have been allocated reference numeral with the same last two significant digits. In this alternative embodiment, the inner circumference of the stator 122 is interrupted by cavities 144 relating to the first phaser output member 128, but also by cavities 146 relating to the second phaser 130. Because the vanes 152 of the second phaser 130 are no longer enclosed by the cavity 146, the radially inner sealing element 156 runs directly on the outer circumference of the first phaser output member 128. Such a configuration has the benefit of simplifying manufacture of the stator 122 because, for example, circumferential slots 62 are no longer required. This therefore reduces manufacturing time and cost. Such a configuration is, however, at the expense of bearing area support for the stator 122.

**[0024]** Figure 5 shows an intermeshing locking pin assembly 64 having three components, namely a pin 66, a spring 68, and a spring seat 70. The pin 66 is cylindrical in shape, and is hollow for receiving the spring 68, and comprises one or more circumferentially spaced axially extending slots 72 in its side wall. The spring seat 70, which may be a formed sheet metal part, has a generally disk like end plate with axially extending protrusions 74 from its perimeter. The seat 70 could take other forms if manufactured from other processes (e.g., sintering or metal injection moulding, etc.). The protrusions 74 on the seat 70 match and align with the slots 72 on the pin 66, so as to engage one another to prevent relative rotation and allow the protrusions 74 to slide within the slots 72 as the pin 66 moves between locked and unlocked positions. A spring guide 76 may also be provided on the end plate of the spring seat to ensure the spring 68 is supported against buckling during compression.

**[0025]** The compression spring 68 acts on the spring seat 70 to urge the pin 66 away from the spring seat 70 into the locked position, thereby extending the pin 66 as shown in figure 6a, when hydraulic pressure that forces the spring to compress is below a pre-set threshold. This then locks the appropriate phaser output member 28, 30 for rotation with the stator 22. If hydraulic pressure is sufficient, the retracted position shown in figure 6b is adopted which allows rotation of the phaser output member 28, 30 relative to the stator 22. The axial position of the lock pin is at all times defined by the balance of forces between the hydraulic pressure acting on its end, and the restorative spring force. The hydraulic pressure acting to unlock (retract) it, the spring force acting to lock (extend) it.

**[0026]** The locking pin assembly 64 may be used in an axial or radial orientation, and so may be used to lock rotation of either the first phaser output member 28, the second phaser output member 30, or both. The advantage of using a locking pin arrangement with matching protrusions and slots is that the overall length of the pin assembly 64 can be reduced, whilst still maintaining the pin length required for adequate engagement in a phaser. This reduction in length is particularly useful when the assembly 64 is disposed axially in relation to the camshaft 10, as it allows the packaging requirements of the phaser, and therefore the engine as a whole, to be reduced. This is critical for heavy duty applications as explained above, where the axial dimension needs to be minimised which may allow the engine to be used across multiple machines.

**[0027]** The locking device is housed within a member with the protrusions 74 of the seat 70 aiding alignment and security of the assembly 64. Where disposed axially, the member may be the stator 22 having an axial through bore 78 (as shown in figures 2, 3, 4, 6a and 6b). When disposed radially, the member may be a housing 80 (shown most clearly in figures 2, 7, and 8) which can be located within the stator 22. The spring seat 70 is an interference fit within the housing 80 or through bore 78, with the axial protrusions 74 increasing the area of interference.

**[0028]** During operation, hydraulic pressure acts on the end of the pin 66. If the hydraulic pressure is under a specified threshold, the spring force is sufficient such that the locking pin 66 remains in a hole, slot, indentation or similar 82, 84 provided in the first and second phaser output members 28, 30, as shown in figure 6a. In the extended position, the protrusions 74 of the spring seat 70 must retain a minimum engagement into the locking pin slots 72. This is to ensure that the spring seat 70 and locking pin 66 are unable to rotate into misalignment relative to each other and lock the pin in the extended position and prevent it from retracting. When the force exerted by the pressurised oil exceeds the installed spring force, the locking pin 66 retracts from the hole 82 in the outer diameter of the first phaser output member 28, as shown in figure 6b, and/or the hole 84 formed in the first end plate 30a of the second phaser 30. Once this retraction has occurred, the phaser output members 28, 30 are able to rotate relative to the stator 22. Due to sufficient clearance, both radially and axially between the spring seat protrusions 74 and the lock pin slots 72, the locking pin 66 is not restricted through its range of motion and is able to fully retract into the stator 22.

**[0029]** In some embodiments, the hub constituting the first phaser output member 28 is formed using a process of sintering from powdered metal as shown in figure 8. In such embodiments, the hole 82 may instead be a slot 182. Such a configuration allows the slot 182 to be formed during the compaction step of the sintering process, thereby reducing the cost of manufacture.

**[0030]** The above-described phaser system 18 may also make use of a spiral spring 32 in order to improve the performance balance of the system. As shown in figure 9, the spiral spring 32 follows the form of a square inner fixation 36 and then spirals radially outward towards the outer diameter of the spring cover 34, and hooks around a peg 86 provided on the stator 22. The spring cover 34 may cover the entire spring 32 and also provides a camshaft position sensor target.

**[0031]** It should be noted that the above description describes only a small number of possible embodiments and should not be interpreted as limiting. Various modifications or adaptations may be made by the skilled person without departing from the scope of the appended claims. For example, the inner shaft of the concentric camshaft may be tubular. In another example, the slot 40 and protrusion interface between the second end plate 30b of the second phaser 30 and the inner shaft 24 may be switched, meaning that the inner shaft features a slot into which protrusions of the second phaser fit. Further, the vanes 48 of the first phaser output member 28 may be integrally formed with the main hub of the phaser.

**[0032]** It will be appreciated that the above description describes the mechanical locking pin assembly in the context of a specific type of phasing system in a specific heavy-duty engine. The description is exemplary and provided for context, and it can be seen that the assembly has other uses. Such uses include a different phasing system to that described, in a phaser in a light duty engine, or in a phasing system which only controls one group of cam lobes. The phaser need not be for controlling the phasing of concentric camshafts. Further, the assembly need not be disposed in a stator, but can instead be disposed in the output member of a phaser itself if desired.

**[0033]** The skilled person will appreciate that the protrusions 74 may be of any number, size or shape, and may be manufactured by any method known in the art. This also applies to the size and manufacturing method of the pin 66 and spring 68.

## Claims

**1.** A mechanical locking pin assembly for mounting within a through bore in a member comprising:

a hollow cylindrical locking pin retractable into the through bore and having an extended position protruding from the member,
a spring seat for mounting within the through bore to grip the inner wall of the through bore; and
a spring disposed within the locking pin and acting on the spring seat to urge the locking pin away from the spring seat toward the extended position,
wherein the spring seat comprises an end plate and plurality of protrusions extending axially from the perimeter of the end plate toward the locking pin, and
wherein complimentary axially extending slots are formed in the cylindrical side wall of the locking pin for receiving the protrusions of the spring seat, in both the extended and retracted positions of the locking pin.

**2.** The locking pin assembly of claim 1, wherein the spring seat is a sheet metal part.

**3.** The locking pin assembly of claim 1 or 2, wherein the end plate of the spring seat further comprises a spring guide.

**4.** A phaser for a camshaft of an internal combustion engine, having a stator to be driven by a crankshaft of the engine and an output member to be connected for rotation with at least some valve actuating cam lobes of the engine, comprising a locking pin assembly as claimed in any preceding claim for locking the stator to the output member in some operating conditions of the engine.

**5.** The phaser of claim 4, wherein the camshaft is a concentric camshaft comprising an outer tube connected for rotation with a first group of cam lobes, and an inner shaft connected for rotation with a second group of cam lobes.

**6.** The phaser of claim 5, wherein the locking pin assembly is disposed within the stator.

**7.** The phaser of any of claims 4 to 6, wherein the locking pin assembly is disposed axially with respect to the camshaft.

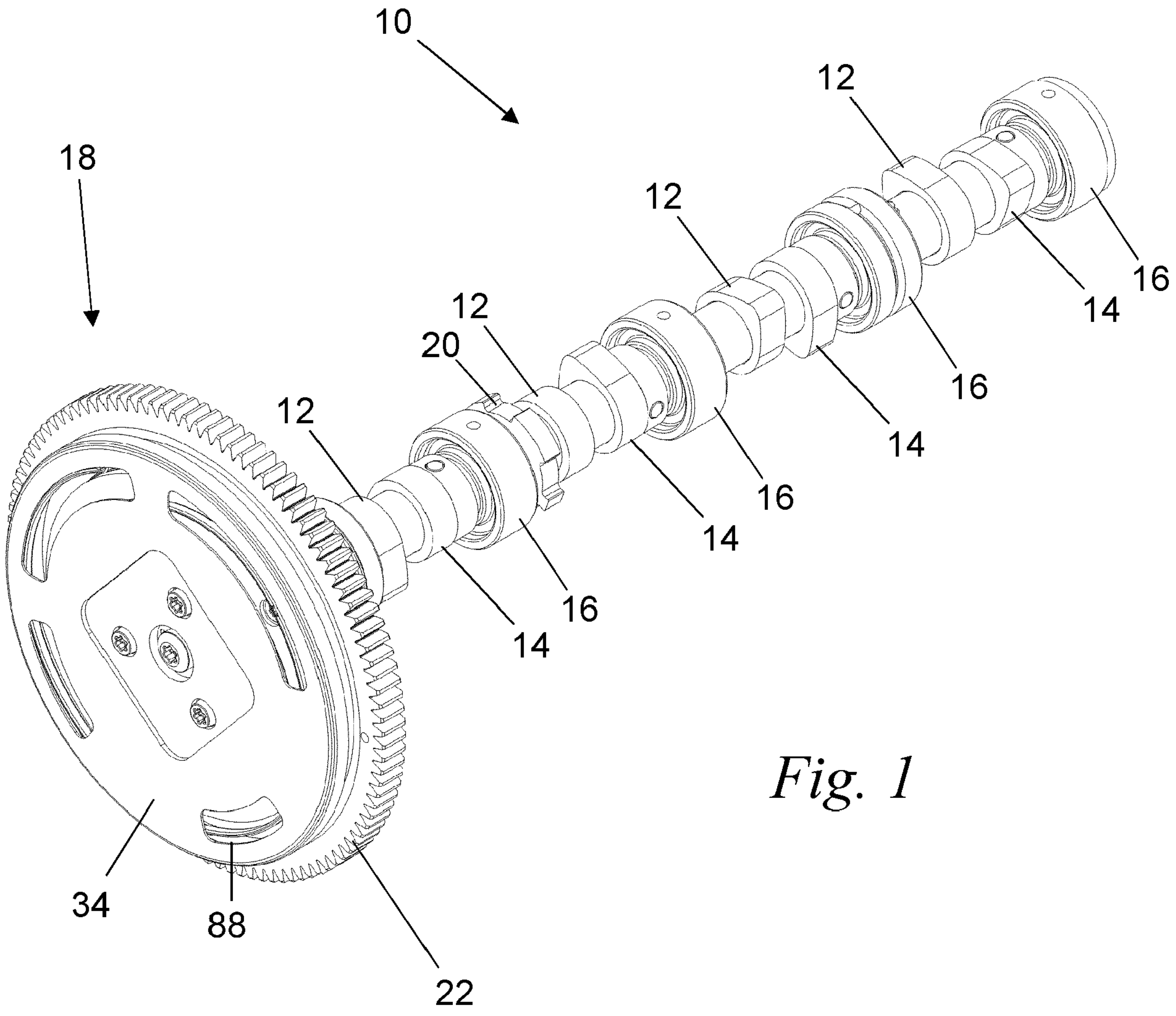


*Fig. 1*

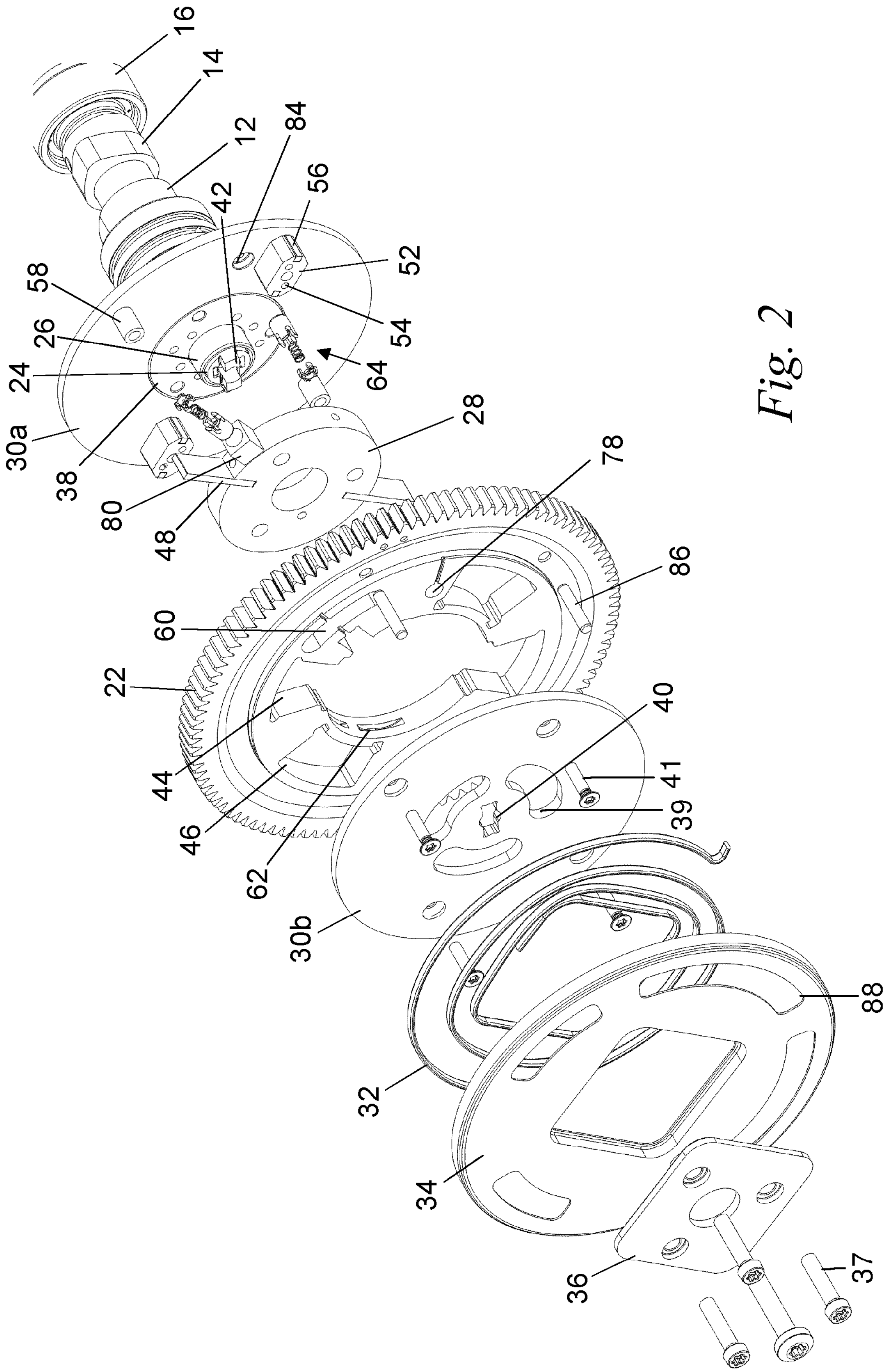
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*Fig. 2*

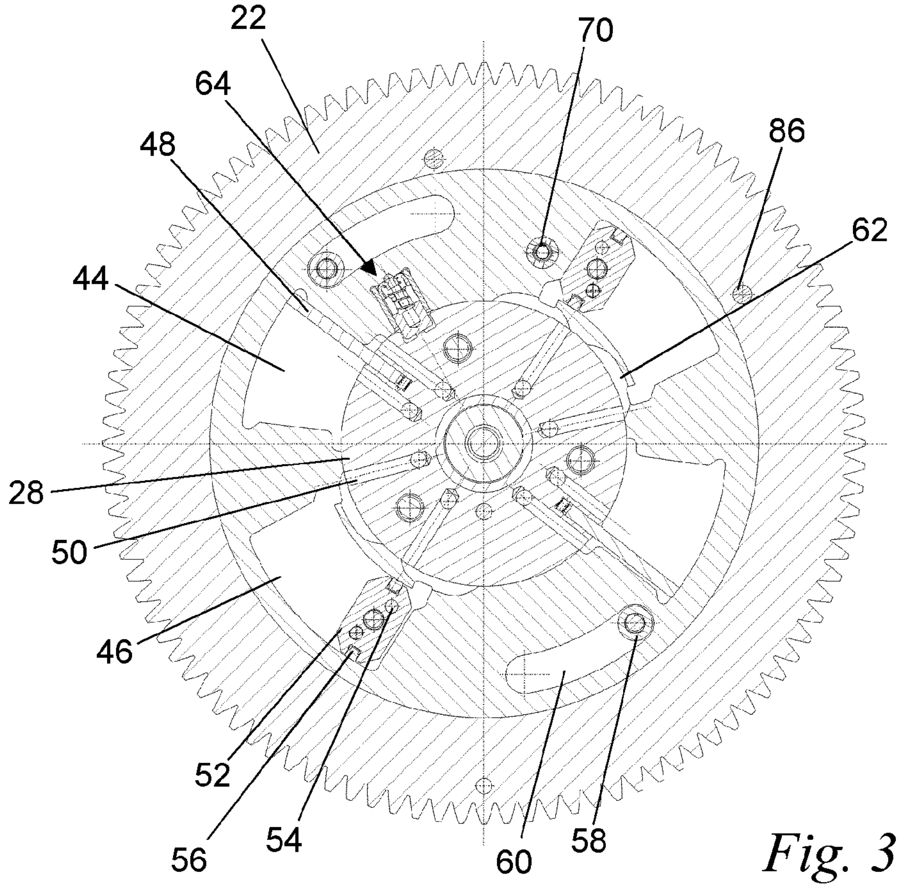


*Fig. 3*

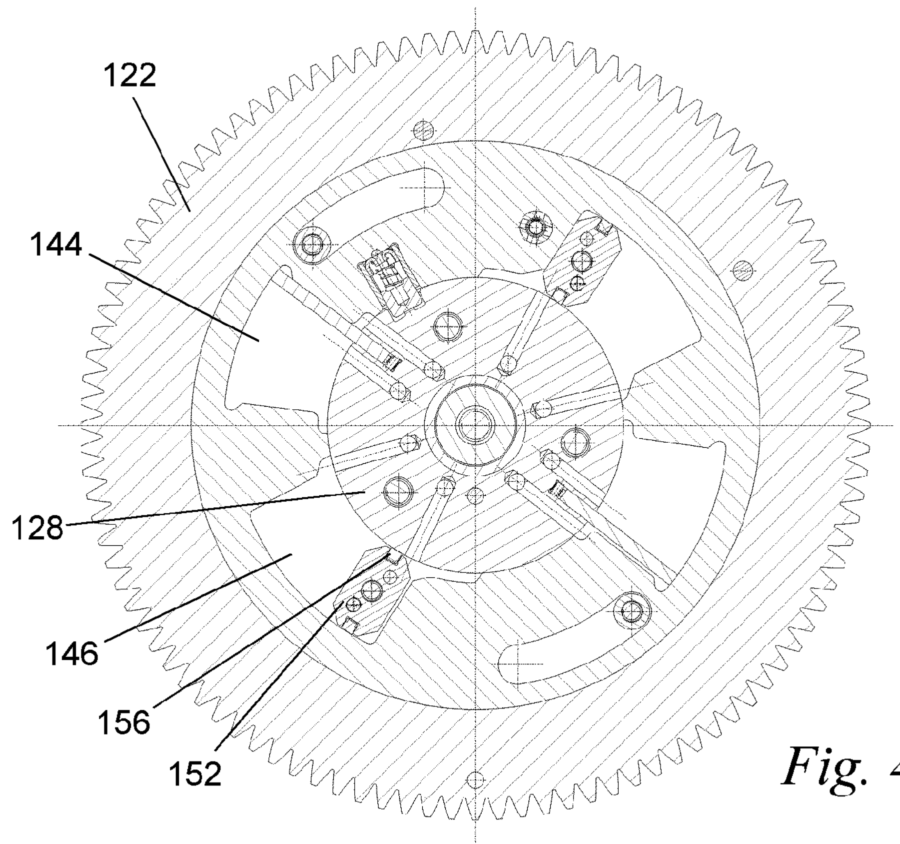


*Fig. 4*

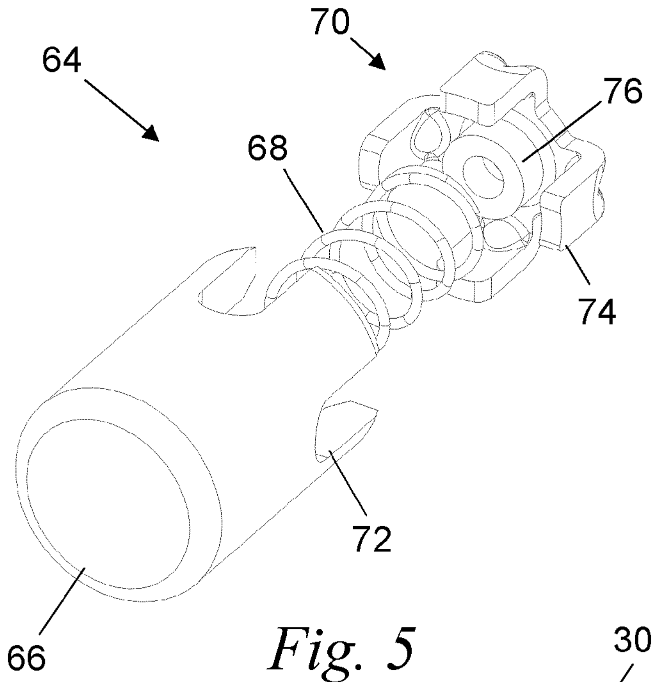


*Fig. 5*

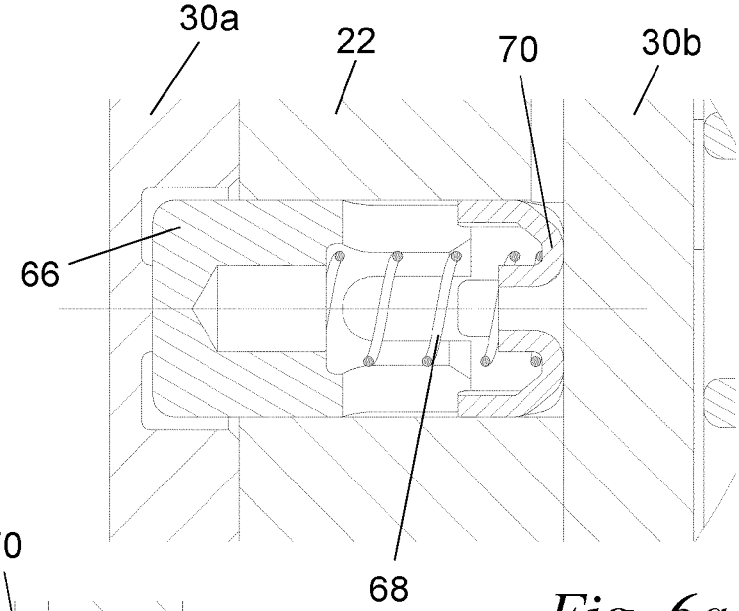


*Fig. 6a*

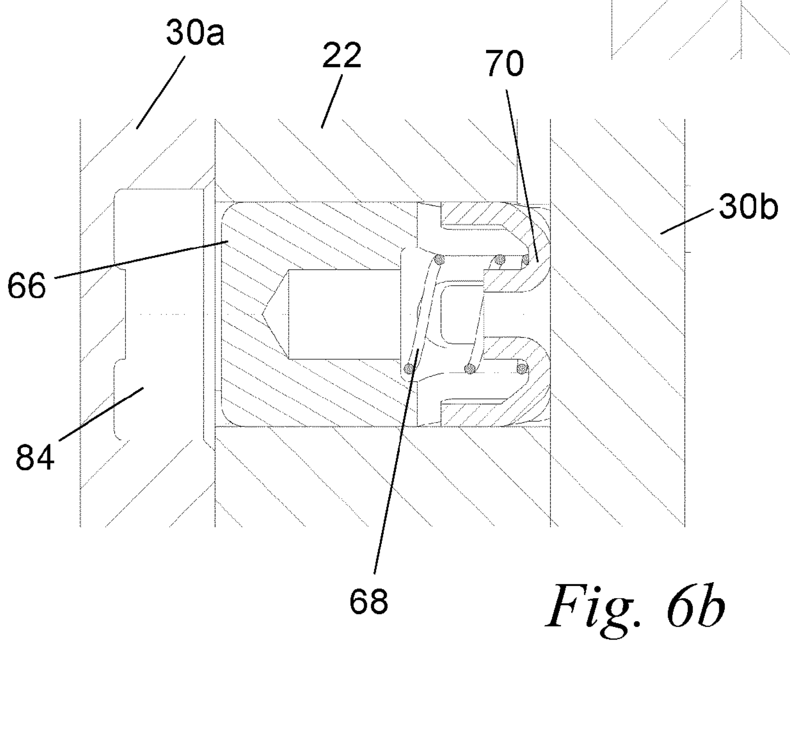


*Fig. 6b*

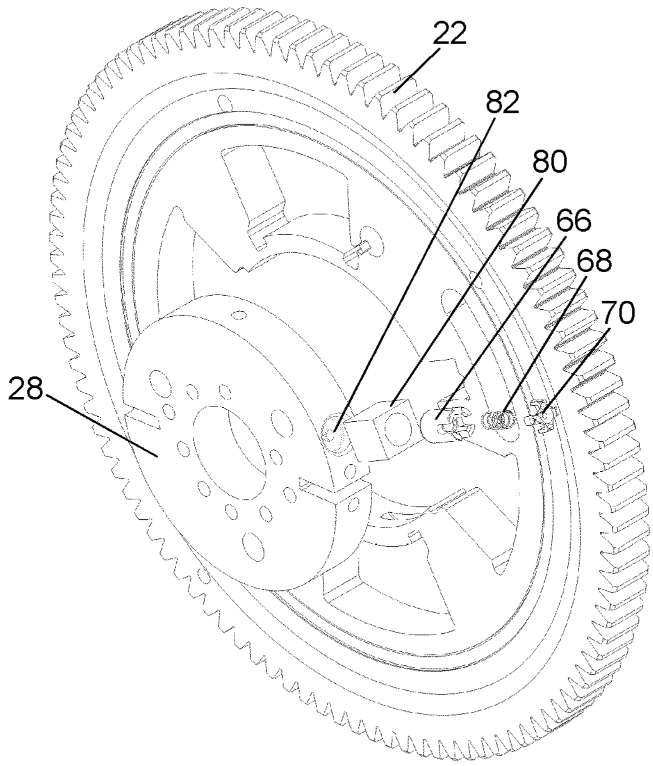


*Fig. 7*

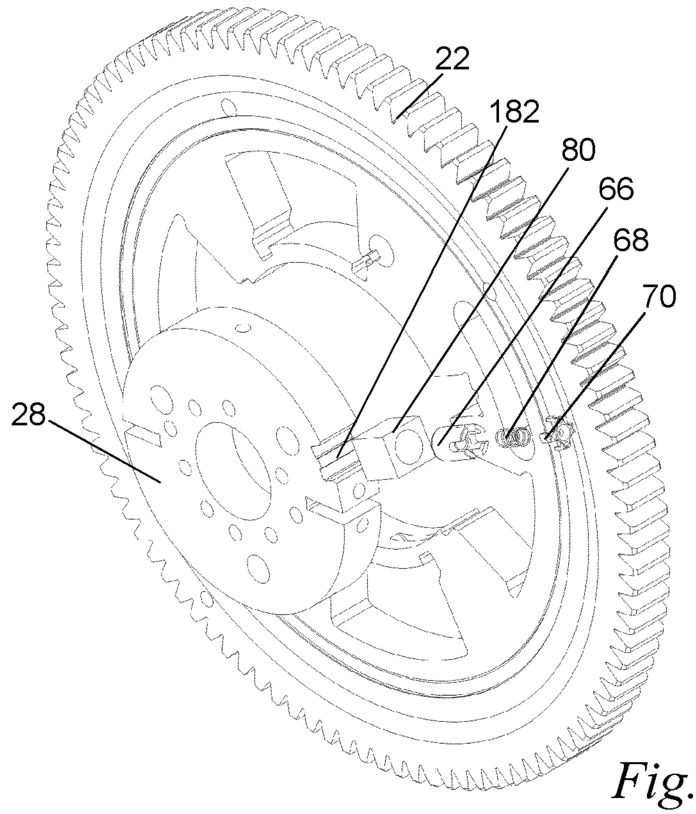


*Fig. 8*

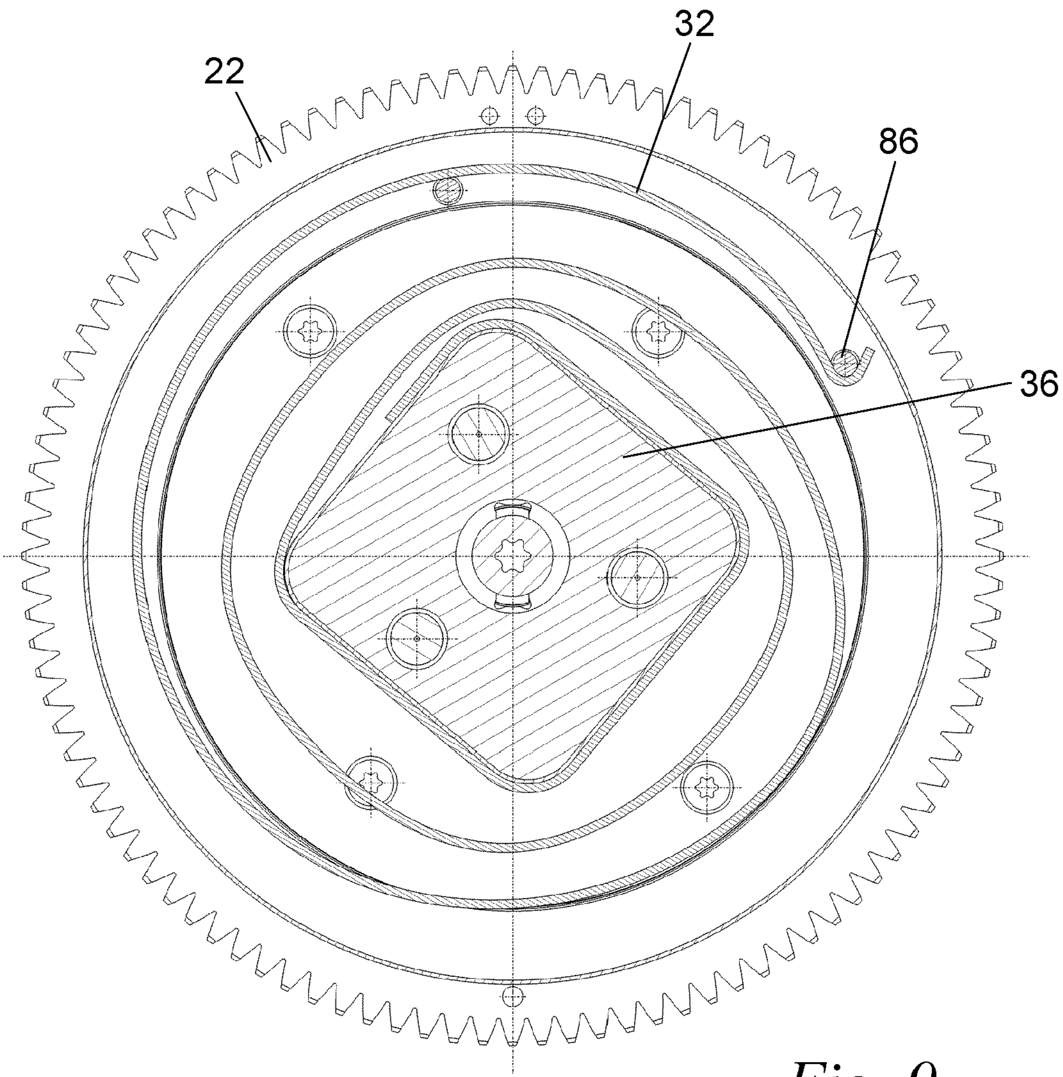


*Fig. 9*

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# EUROPEAN SEARCH REPORT

Application Number
EP 22 19 3563

## DOCUMENTS CONSIDERED TO BE RELEVANT

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The present search report has been drawn up for all claims

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| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 14 February 2023 | Van der Staay, Frank |

CATEGORY OF CITED DOCUMENTS

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 19 3563

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