(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 826 964 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.01.2015 Bulletin 2015/04

(51) Int Cl.:
F01L 1/348 *(2006.01)*

(21) Application number: **13176545.5**

(22) Date of filing: **15.07.2013**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

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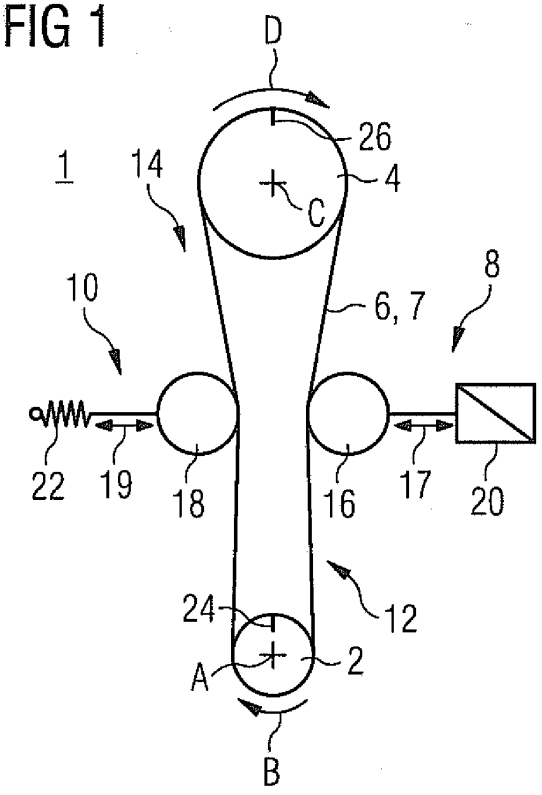
(54) **Variable actuation timing device**

(57) The present disclosure relates to a variable actuation timing device (1) in which a drive mechanism (6) may drivingly couple a crankshaft (2) to a first camshaft (4). A first adjustment device (8) including a first adjustment member (16) may be arranged and configured to cause a change in length of a drive mechanism path (7) on a tight side (12) to change an angle of rotation of the first camshaft (4) relative to the crankshaft (2). A compensation device (10) including a compensation member (18) may be arranged and configured to compensate the change in length of the drive mechanism path (7) on a slack side (14). Thus, a robust variable actuation timing device at reasonable manufacturing costs may be provided.

FIG 1



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Description

Technical Field

[0001] The present disclosure relates to internal combustion engines, and more particularly to a method and device for varying actuation timings of cam actuated components in an internal combustion engine.

Background

[0002] Various systems are known in the field of variable valve timing technology. Those systems aim to adjust actuation timings of cam actuated components in an internal combustion engine. Most variable valve timing devices facilitate a so-called cam-phasing, where a rotational angle of a camshaft is rotated forwards or backwards relative to a crankshaft. Some systems may even allow varying actuation durations. Adjustment of valve timings can be performed to increase engine efficiency depending on a present engine load. The increased engine efficiency may be noteable in decreased fuel consumption, increased engine output, and/or increased engine torque.

[0003] For example, variable valve timing devices may be included in driven wheels of camshafts. However, those systems may have high manufacturing costs and may not be able to provide the required robustness necessary for the hostile environmental conditions of an internal combustion engine.

[0004] The present disclosure is directed, at least in part, to improving or overcoming one or more aspects of prior systems.

Summary of the Disclosure

[0005] According to one aspect of the present disclosure, a variable actuation timing device is disclosed. The variable actuation device for varying an actuation timing of a cam actuated component of an internal combustion engine may comprise a first camshaft configured to actuate the cam actuated component. The variable actuation device may further comprise a crankshaft, a drive mechanism drivingly coupling the crankshaft to the first camshaft, and a first adjustment device. The first adjustment device may include a first adjustment member configured to engage with the drive mechanism. The first adjustment device may be arranged and configured to cause a change in length of a drive mechanism path on a tight side of the drive mechanism to change an angle of rotation of the first camshaft relative to the crankshaft. The variable actuation device may further comprise a compensation device including a compensation member configured to engage with the drive mechanism. The compensation device may be arranged and configured to compensate the change in length of the drive mechanism path on a slack side of the drive mechanism.

[0006] According to another aspect aspect of the present disclosure, a method for varying an actuation timing of a component actuated by a camshaft drivingly coupled to a crankshaft via a drive mechanism in an internal combustion engine by varying an angle of rotation of the camshaft relative to the crankshaft is disclosed. The method may comprise changing a length of a drive mechanism path on a tight side of the drive mechanism, and simultaneously compensating the change in length on a slack side of the drive mechanism.

[0007] Other features and aspects of this disclosure will be apparent from the following description and the accompanying drawings.

Brief Description of the Drawings

[0008] The accompanying drawings, which are incorporated herein and constitute a part of the specification, illustrate exemplary embodiments of the disclosure and, together with the description, serve to explain the principles of the disclosure. In the drawings:

Fig. 1 is a schematic drawing of a variable actuation timing device according to a first embodiment of the present disclosure;

Fig. 2 is a schematic drawing of a variable actuation timing device according to a second embodiment of the present disclosure;

Fig. 3 is a schematic drawing of the variable actuation timing device according to the first embodiment in another operational state compared to the one shown in Fig. 1;

Fig. 4 is a schematic drawing of the variable actuation timing device according to the first embodiment in yet another operational state compared to the one shown in Fig. 1;

Fig. 5 is a schematic drawing of a variable actuation timing device according to a third embodiment of the present disclosure;

Fig. 6 is a schematic drawing of a variable actuation timing device according to a fourth embodiment of the present disclosure;

Fig. 7 is a schematic drawing of the variable actuation timing device according to the fourth embodiment in another operational state compared to the one shown in Fig. 6;

Fig. 8 is a schematic drawing of the variable actuation timing device according to the fourth embodiment in yet another operational state compared to the one shown in Fig. 6; and

[0009] Fig. 9 shows an exemplary cam actuation arrangement of an internal combustion engine.

Detailed Description

[0010] The following is a detailed description of exemplary embodiments of the present disclosure. The exemplary embodiments described therein and illustrated in

the drawings are intended to teach the principles of the present disclosure, enabling those of ordinary skill in the art to implement and use the present disclosure in many different environments and for many different applications. Therefore, the exemplary embodiments are not intended to be, and should not be considered as, a limiting description of the scope of patent protection. Rather, the scope of patent protection shall be defined by the appended claims.

[0011] The present disclosure is based in part on the realization that a change of a drive mechanism path of a drive mechanism which drivingly couples a crankshaft with a camshaft can be used to vary an angle of rotation of the camshaft relative to the crankshaft. Thus, a variable valve timing technology can be provided. Specifically, a camshaft can be rotated forward or backward with respect to the crankshaft by increasing or decreasing a length of the drive mechanism path on a tight side of the drive mechanism while compensation the change in length on a slack side of the drive mechanism, respectively.

[0012] Hereinafter, exemplary variable valve timing devices which facilitate changing lengths of driving mechanism paths on the tight side and the slack side of the drive mechanism are disclosed.

[0013] Referring to Fig. 1, a variable valve timing device is referred to in its entirety with reference numeral 1. Variable actuation timing device 1 comprises a crankshaft 2, a camshaft 4, and a drive mechanism 6. In addition, an adjustment device 8 and a compensation device 10 are included in variable actuation timing device 1.

[0014] Crankshaft 2 is rotatably supported within a crankcase of an internal combustion engine (both not shown) and rotatable about a crankshaft axis A in a rotational direction B.

[0015] Said internal combustion engine comprising variable valve timing device 1 may include features not shown, such as air systems, cooling systems, peripheries, drivetrain components, etc. Furthermore, the internal combustion engine may be of any size, with any number of cylinders, and in any configuration (for example, "V," in-line, radial, etc.). Additionally, the internal combustion engine may be used to power any machine or other device, including, but not limited to, locomotive applications, on-highway trucks or vehicles, off-highway trucks or machines, earth moving equipment, generators, aerospace applications, marine applications, offshore applications, pumps, stationary equipment, or other engine powered applications. The internal combustion engine may be powered with any fuel including, but not limited to, diesel, gasoline, and/or gaseous fuels.

[0016] Camshaft 4 is rotatably supported and rotatable about a camshaft axis C in a rotational direction D. To actuate various cam actuated components such as, for example, inlet valves, outlet valves, and/or fuel pumps, camshaft 4 is provided with a plurality of cams not shown in detail.

[0017] To drivingly couple camshaft 4 to crankshaft 2, drive mechanism 6 is provided. Said drive mechanism 6 may be, for example, a drive chain, or a drive belt such as a toothed drive belt. Specifically, drive mechanism 6 loops around a drive wheel (not shown in detail) of crankshaft 2 and a driven wheel (not shown in detail) of camshaft 4 along a drive mechanism path 7.

[0018] Drive mechanism path 7 is defined by drive and driven wheels of crankshaft 2 and camshaft 4 as well as an adjustment member 16 of adjustment device 8 and a compensation member 18 of compensation device 10. Both adjustment member 16 and compensation member 18 are engaged with drive mechanism 6. In other words, adjustment member 16 as well as compensation member 18 contact drive mechanism 6. Thereby, drive mechanism 6 is guided by the relevant member 16, 18, for example, along an outer shape of the relevant member 16, 18, or by a wheel rotating with the movement of drive mechanism 6.

[0019] Considering given rotational direction B of crankshaft 2 which drives drive mechanism 6 and camshaft 4, a tight side 12 and a slack side 14 of drive mechanism 6 (and of drive mechanism path 7) are provided as shown. Specifically, tight side 12 is the loaded side of drive mechanism 6 which is pulled by crankshaft 2, whereas slack side 14 is the return side of drive mechanism 6, which is also known as the loose side.

[0020] As indicated by a double-ended arrow 17 in Fig. 1, adjustment member 16 is displaceable toward and away from drive mechanism 6. To displace adjustment member 16, adjustment device 8 includes an adjustment actuator 20 which, in the shown configuration, facilitates displacing adjustment member 16 in a direction perpendicular to a moving direction of drive mechanism 6 at a contact point of adjustment member 16 and drive mechanism 6. Alternatively or additionally, adjustment device 8 may be configured to displace adjustment member 16 parallel to the moving direction of drive mechanism to change a length of drive mechanism path 7 on tight side 12 thereof.

[0021] Adjustment actuator 20 may be any type of actuator capable to displace adjustment member 16. For example, adjustment actuator 20 may be a mechanical actuator, an electric actuator, a hydraulic actuator, and/or a pneumatic actuator. Examples of mechanical actuators include levers and eccentrics. In case adjustment actuator 20 is a hydraulic actuator such as a single acting hydraulic cylinder, a single acting hydraulic cylinder with spring return, or a double acting hydraulic cylinder, the hydraulic actuator may be fluidly connected to an engine lubrication path providing a required hydraulic pressure to operate the hydraulic actuator.

[0022] To compensate a change in length on tight side 12 of drive mechanism path 7 caused by adjustment device 8, compensation device 10 with compensation member 18 is provided. Compensation member 18 is biased against drive mechanism 6 by compensation spring 22 which allows displacements of compensation member 18 toward and away from drive mechanism 6 as indicated

by a double-ended arrow 19 in Fig. 1.

[0023] In the shown configuration, adjustment member 16 and compensation member 18 are designed as wheels such as, for example, sprockets or rollers. In other embodiments, at least one of adjustment member 16 and compensation member 18 may be designed as a rail.

[0024] Depending on, for example, a desired degree of control over the variable actuation timing, and a design of adjustment device 8 and compensation device 10, both may be either capable to continuously displace or to discretely displace adjustment member 16 and compensation member 18, respectively.

[0025] In some embodiments, guidances for adjustment member 16 and compensation member 18 may be provided to guide members 16 and 18 during displacement of the same. For example, said guidances may be configured as slide bars.

[0026] It should be noted that in Fig. 1 and subsequent Figs. 2 to 8, rotational angle marks are schematically provided at crankshaft 2 and camshaft 4 to indicate relative rotational angle changes as a result of operating variable actuation timing device 1. Specifically, a rotational angle mark of crankshaft 2 is indicated by reference numeral 24, and a rotational angle mark of camshaft 4 is indicated by reference numeral 26.

[0027] Turning to Fig. 2, a second embodiment of variable actuation timing device 1 is shown which differs from the first embodiment shown in Fig. 1 in that compensation device 10 comprises a compensation actuator 28 instead of a compensation spring 22 (see Fig. 1).

[0028] Similar to adjustment actuator 20, compensation actuator 28 may be, for example, a mechanical actuator, an electric actuator, a hydraulic actuator, and/or a pneumatic actuator. In case compensation actuator 28 is a hydraulic actuator, the same may be fluidly connected to an engine lubrication path providing a required hydraulic pressure to operate the hydraulic actuator.

[0029] Skipping Figs. 3 and 4, which are described later on in connection with the discussion of the operation and functionality of variable actuation timing device 1, in the following, Fig. 5 is referred to. Fig. 5 shows a third embodiment of variable actuation timing device 1. Here, the configuration of variable actuation timing device 1 is similar to the one shown in Fig. 1 except that a second camshaft 30 is provided. Second camshaft 30 is rotatably supported and rotatable about a second camshaft axis E in a rotational direction F. Similar to first camshaft 4, second camshaft 30 is drivingly coupled to crankshaft 2 via drive mechanism 6.

[0030] For example, first camshaft 4 may be configured and arranged as an inlet valve camshaft to operate a plurality of inlet valves of cylinder units of the internal combustion engine (not shown). Second camshaft 30 may then serve to operate a plurality of outlet valves.

[0031] In the shown configuration, adjustment member 16 of adjustment device 8 is engaged with drive mechanism 6 between first camshaft 4 and second camshaft 30 at a first section of tight side 12. Alternatively, adjustment device 8 may be arranged and configured such that adjustment member 16 engages with drive mechanism 6 between second camshaft 30 and crankshaft 2 at a second section of tight side 12 to cause a change in length of a drive mechanism path 7 when displaced.

[0032] Similar to marks 24 and 26, a second camshaft rotational angle mark 32 schematically indicates a rotational angle of second camshaft 30 relative to a rotational angle of crankshaft 2 and to a rotational angle of camshaft 4.

[0033] Turning to Fig. 6, a further embodiment of variable actuation timing device 1 is shown which differs from the configuration of variable actuation timing device 1 in Fig. 5 in that a second adjustment device 34 is provided.

[0034] Second adjustment device 34 includes a second adjustment member 38 and a second adjustment actuator 36. Similar to first adjustment actuator 20, second adjustment actuator 36 may be any type of actuator capable to either continuously or to discretely displace second adjustment member 38 as indicated by a double-ended arrow 39.

[0035] Referring to Fig. 9, an exemplary cam actuation arrangement is depicted very schematically. As can be seen, a cam 40 of camshaft 4 moves a rocker arm mechanism 44 via a cam follower 42. Rocker arm mechanism 44 in turn actuates an inlet valve 46. Accordingly, in the shown arrangement, the cam actuated component is exemplified by inlet valve 46. Additionally or alternatively, further cam actuated components may be present in the internal combustion engine, such as, for example, a fuel injector 48, an outlet valve 50, and/or a fuel pump (not shown).

Industrial Applicability

[0036] In the following, operation and functionality of variable actuation timing device 1 is described. As examples, operation and functionality of the first described embodiment of variable actuation timing device 1 is explained with reference to Figs. 1, 3, and 4, and operation and functionality of the fourth described embodiment of variable actuation timing device 1 is explained with reference to Figs. 6 to 8.

[0037] Referring first to the first embodiment as depicted in Figs. 1, 3 and 4. As already mentioned, crankshaft 2 and first camshaft 4 are schematically provided with rotational angle marks 24 and 26, which help to describe the effect of a displacement of adjustment member 16.

[0038] In the depicted operational state of Fig. 1, adjustment device 8 and compensation device 10 are in an intermediate extension position. In case it is desired to rotate camshaft 4 forward relative to crankshaft 2, adjustment device 8 can extend and displace adjustment member 16 toward drive mechanism 6. Thereby, adjustment member 16 pushes drive mechanism 6 in the direction of extension. This results in an increased drive mechanism path 7 on tight side 12 as can be seen in Fig.

3. As drive mechanism 6 is engaged with camshaft 4, the same is rotated forward as long as adjustment member 16 is further displaced toward drive mechanism 6. As a result, an angle of rotation of first camshaft 4 relative to an angle of rotation of crankshaft 2 is brought forward.

[0039] To facilitate said rotation of camshaft 4 relative to crankshaft 2, the increase in length on tight side 12 needs to be compensated as drive mechanism 6 and, therefore, also drive mechanism path 7 are of a substantial constant length. The increase in length on tight side 12 is compensated by a substantially synchronous decrease in length of drive mechanism path 7 on slack side 14. Specifically, compensation device 10 retracts compensation member 18. This may be performed passive as a counterforce on spring 22 which biases compensation member 18 against drive mechanism 6 increases due to the effect of pushing adjustment member 16 against drive mechanism 6 on tight side 12. Additionally or alternatively, compensation may be at least partially performed actively by an active retraction of compensation member 18 to shorten drive mechanism path 7 on slack side 14. For example, compensation actuator 28 of the embodiment shown in Fig. 2 may actively retract compensation member 18.

[0040] When comparing rotational angle marks 24 and 26 of Figs. 1 and 3, it can be seen that in the operational state of Fig. 3, camshaft 4 is rotated forward relative to crankshaft 2 as a result of the change in length. As one skilled in the art will appreciate, a rotational angle of crankshaft 2 is not changed by length changes on tight side 12 and slack side 14 as crankshaft 2 is driven by reciprocating pistons during operation.

[0041] On the other hand, if retracting adjustment device 8 as illustrated in Fig. 4, camshaft 4 can be rotated backwards relative to crankshaft 2. Specifically, a retraction of adjustment member 16 causes a decrease in length of drive mechanism path 7 on tight side 12. The decrease in length on tight side 12 results in a rotation backwards of camshaft 4 as tension of drive mechanism 6 on tight side 12 is released during retraction and camshaft 4 takes a new balance rotational angle which lies backward of the former rotational angle. As a result, rotational angle of camshaft 4 is shifted backwards relative to rotational angle of crankshaft 2 which can be also seen by marks 24 and 26 in Fig. 4. The shortening of drive mechanism path 7 on tight side 12 is compensated by compensation member 18 pushing against drive mechanism 6 on slack side 14.

[0042] In other words, to vary an actuation timing of a cam actuated component, an angle of rotation of camshaft 4 relative to crankshaft 2 is varied by changing a length of drive mechanism path 7 on tight side 12 while simultaneously compensating the change in length of drive mechanism path 7 on slack side 14. As described herein, changes in length on tight side 12 and slack side 14 may be cause by providing a variable actuation timing device 1 as exemplary disclosed herein.

[0043] In particular, increasing a length of drive mechanism path 7 on tight side 12 while decreasing a length of drive mechanism path 7 on slack side 14 rotates camshaft 4 forward relative to crankshaft 2. On the other hand, decreasing a length of drive mechanism path 7 on tight side 12 while increasing a length of drive mechanism path 7 on slack side 14 rotates camshaft 4 backward relative to crankshaft 2.

[0044] In the following, operation of fourth embodiment of variable actuation timing device 1 is described with reference to Figs. 6 to 8. Here, first camshaft 4 and second camshaft 30 can be individually or together rotated relative to each other and to crankshaft 2.

[0045] To change a rotational angle of first camshaft 4, first adjustment device 8 can be extended or retracted to lengthen or shorten drive mechanism path 7 in a first section of tight side 12, which lies between first camshaft 4 and second camshaft 30. Similar to the first embodiment, said lengthening and shortening of tight side 12 while compensating the change in length on slack side 14 by compensation device 10 results in a rotation forward and backward of first camshaft 4 relative to crankshaft 2, respectively. Naturally, first camshaft 4 is at the same time rotated forward and backward relative to second camshaft 30.

[0046] Extension and retraction of second adjustment device 34 leads to a change of a rotational angle of second camshaft 30 and first camshaft 4 relative to crankshaft 2. However, first adjustment device 8 can also be controlled such that solely second camshaft 30 is rotated relative to crankshaft 2. Specifically, first adjustment device 8 can compensate the change in length of drive mechanism path 7 in a second section of tight side 12, which lies between second camshaft 30 and crankshaft 2, caused by second adjustment device 34. More specifically, in case drive mechanism path 7 in the second section of tight side 12 is lengthened by an extension of second adjustment device 34, the first section of tight side 12 of drive mechanism path 7 is shortened by retraction of first adjustment device 8, which is schematically illustrated in Fig. 8. A vice versa operation of first adjustment device 8 and second adjustment device 34 is depicted in Fig. 7. In other words, first adjustment device 8 can function as compensator instead of compensation device 10.

[0047] To control displacement of adjustment members 16, 38 and possibly also of compensation member 18, a control system not shown in detail may be provided. Said control system may control the extension and retraction states based on various parameters including, but not limited to, engine load, and throttle positions. In some embodiments, said control system may form part of an engine control unit (ECU) controlling operation of the internal combustion engine.

[0048] As described above, variable actuation timing device 1 provides a system for cam-phasing in which adjustment devices 8 and/or 34 are provided separate from respective camshafts 4, 30 (from driven wheels of respective camshafts 4, 30). Such a configuration may

be capable to withstand the hostile environment of an internal combustion engine at reasonable manufacturing costs.

[0049] As used herein, the terms "rotated forward", "rotated backward", and "rotated relative to" used in connection with changes in length of drive mechanism path 7 on tight side 12 and slack side 14 are used to describe a relative rotation of camshafts 4 and/or 30 about certain angle values smaller than 360°. Note that those terms used in the above described context do not relate to the rotation during operation with half engine speed expressed in revolutions per minute (rpm).

[0050] Although the preferred embodiments of this invention have been described herein, improvements and modifications may be incorporated without departing from the scope of the following claims.

Claims

1. A variable actuation timing device (1) for varying an actuation timing of a cam actuated component (46, 48, 50) of an internal combustion engine, the variable actuation timing device (1) comprising:

   a first camshaft (4) configured to actuate the cam actuated component (46, 48, 50);
   a crankshaft (2);
   a drive mechanism (6) drivingly coupling the crankshaft (2) to the first camshaft (4);
   a first adjustment device (8) including a first adjustment member (16) configured to engage with the drive mechanism (6), the first adjustment device (8) being arranged and configured to cause a change in length of a drive mechanism path (7) on a tight side (12) of the drive mechanism (6) to change an angle of rotation of the first camshaft (4) relative to the crankshaft (2); and
   a compensation device (10) including a compensation member (18) configured to engage with the drive mechanism (6), the compensation device (10) being arranged and configured to compensate the change in length of the drive mechanism path (7) on a slack side (14) of the drive mechanism (6).

2. The variable actuation timing device (1) of claim 1, wherein
   the first adjustment device (8) is configured to displace the first adjustment member (16) perpendicular to a moving direction of the drive mechanism (6); and/or
   the first adjustment device (8) is configured to displace the first adjustment member (16) parallel to a moving direction of the drive mechanism (6).

3. The variable actuation timing device (1) of claim 1 or 2,
   wherein
   the first adjustment member (16) is configured as a wheel or a rail;
   and/or
   the compensation member (18) is configured as a wheel or a rail.

4. The variable actuation timing device (1) of any one of the preceding claims, wherein the first adjustment device (8) comprises a first adjustment actuator (20) to displace the first adjustment member (16), the first adjustment actuator (20) being configured as a mechanical actuator, an electric actuator, a hydraulic actuator, and/or a pneumatic actuator.

5. The variable actuation timing device (1) of any one of the preceding claims, wherein
   the compensation adjustment device (10) comprises a compensation actuator (28) to displace the compensation member (18), the compensation actuator (28) being configured as a mechanical actuator, an electric actuator, a hydraulic actuator, and/or a pneumatic actuator; and/or
   the compensation adjustment device (10) comprises a spring (22) biasing the compensation member (18) against the drive mechanism (6).

6. The variable actuation timing device (1) of any one of the preceding claims, wherein
   the first adjustment device (8) is further configured to continuously displace the first adjustment member (16); or
   the first adjustment device (8) is further configured to discretely displace the first adjustment member (16).

7. The variable actuation timing device (1) of any one of the preceding claims, further comprising a second camshaft (30) drivingly coupled to the crankshaft (2) by the drive mechanism (6); and wherein
   the first adjustment device (8) is arranged to solely change an angle of rotation of the first camshaft (4) relative to the crankshaft (2); or
   the first adjustment device (8) is arranged to change an angle of rotation of the first camshaft (4) relative to the crankshaft (2) and to change an angle of rotation of the second camshaft (30) relative to the crankshaft (2).

8. The variable actuation timing device (1) of claim 7, further comprising a second adjustment device (34) comprising a second adjustment member (38) configured to engage with the drive mechanism (6), the second adjustment device (34) being arranged and configured to cause a change in length of the drive mechanism path (7) on the tight side (12) to change an angle of rotation of the second camshaft (30) rel-

ative to the crankshaft (2).

9. The variable actuation timing device (1) of claim 8, wherein
the second adjustment device (34) is configured to displace the second adjustment member (38) perpendicular to a moving direction of the drive mechanism (6); and/or
the second adjustment device (34) is configured to displace the second adjustment member (38) parallel to a moving direction of the drive mechanism (6).

10. The variable actuation timing device (1) of claim 8 or 9, wherein the second adjustment member (38) is configured as a wheel or a rail.

11. The variable actuation timing device (1) of any one of claims 8 to 10, wherein the second adjustment device (34) comprises a second adjustment actuator (36) to displace the second adjustment member (38), the second adjustment actuator (36) being configured as a mechanical actuator, an electric actuator, a hydraulic actuator, and/or a pneumatic actuator.

12. The variable actuation timing device (1) of any one of claims 8 to 11, wherein
the second adjustment device (34) is further configured to continuously displace the second adjustment member (38); or
the second adjustment device (34) is further configured to discretely displace the second adjustment member (38).

13. The variable actuation timing device (1) of any one of the preceding claims, wherein the drive mechanism (6) is configured as a drive chain or a drive belt.

14. A method for varying an actuation timing of a component (46, 48, 50) actuated by a camshaft (4) drivingly coupled to a crankshaft (2) via a drive mechanism (6) in an internal combustion engine by varying an angle of rotation of the camshaft (4) relative to the crankshaft (2), the method comprising:

changing a length of a drive mechanism path (7) on a tight side (12) of the drive mechanism (6); and
simultaneously compensating the change in length on a slack side (14) of the drive mechanism (6).

15. The method of claim 14, wherein
changing a length of the drive mechanism path (7) on the tight side (12) of the drive mechanism (6) comprises increasing or decreasing a length of the drive mechanism path (7) on the tight side (12); and
simultaneously compensating the change in length on a slack side (14) of the drive mechanism (6) comprises decreasing or increasing a length of the drive mechanism path (7) on the slack side (14), respectively.

FIG 1

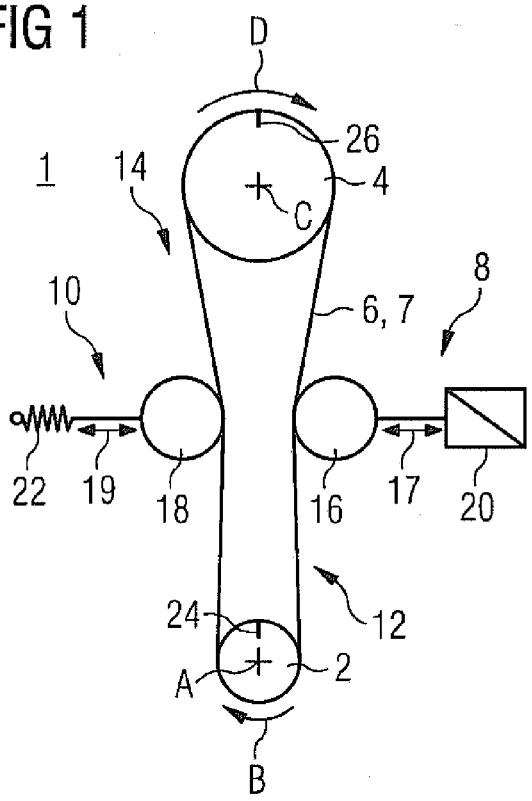
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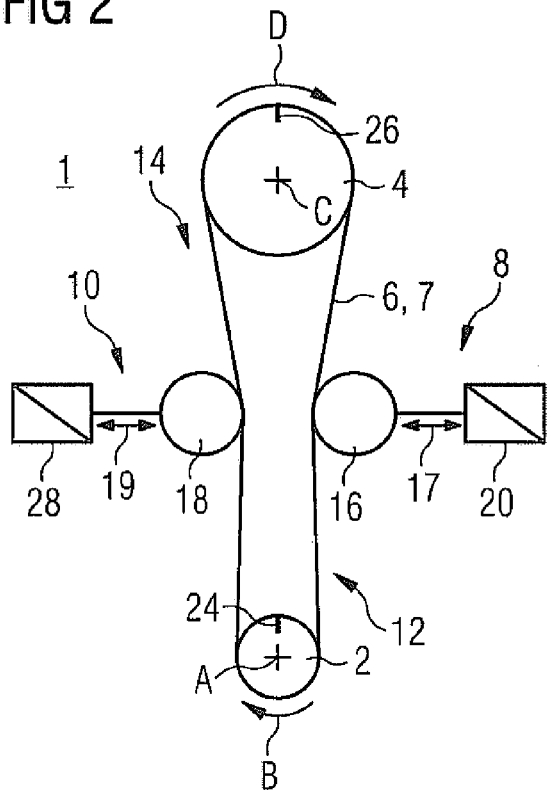
FIG 2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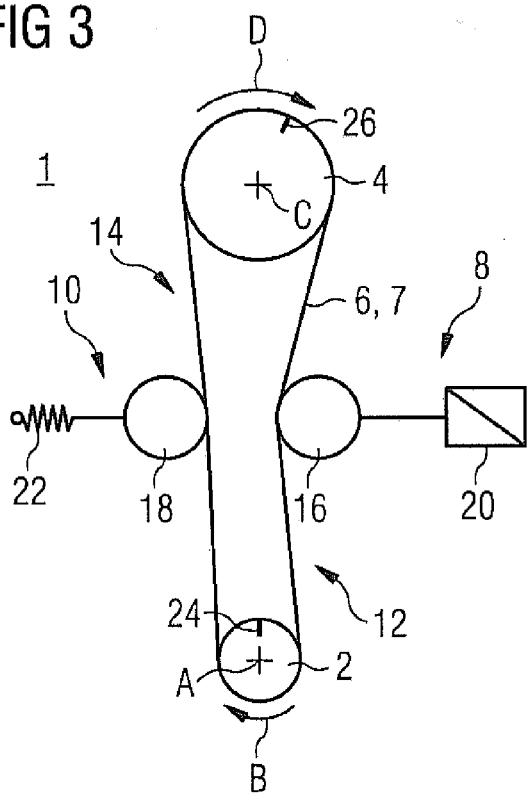
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FIG 4

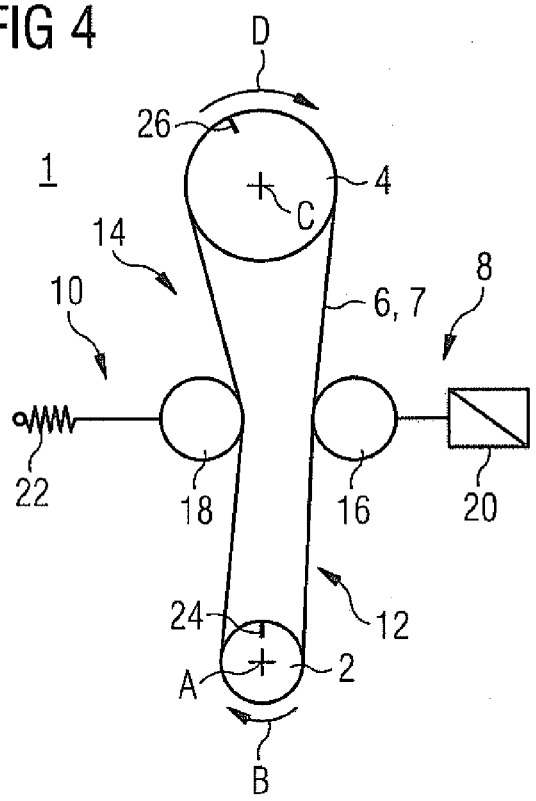
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FIG 5

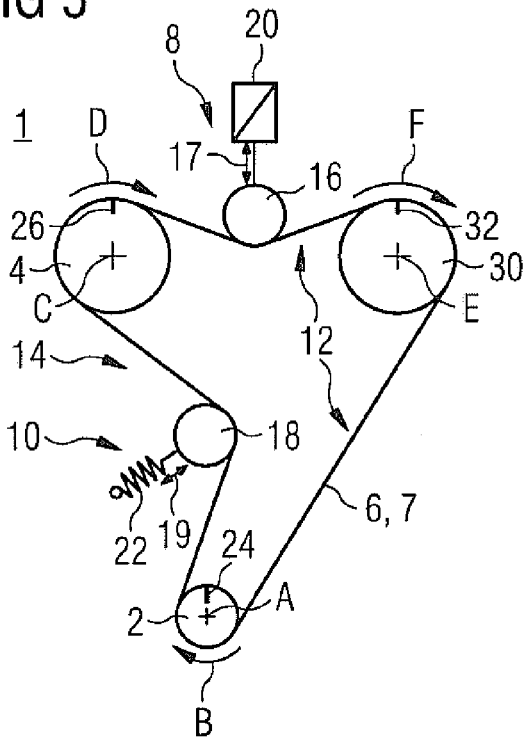
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FIG 6

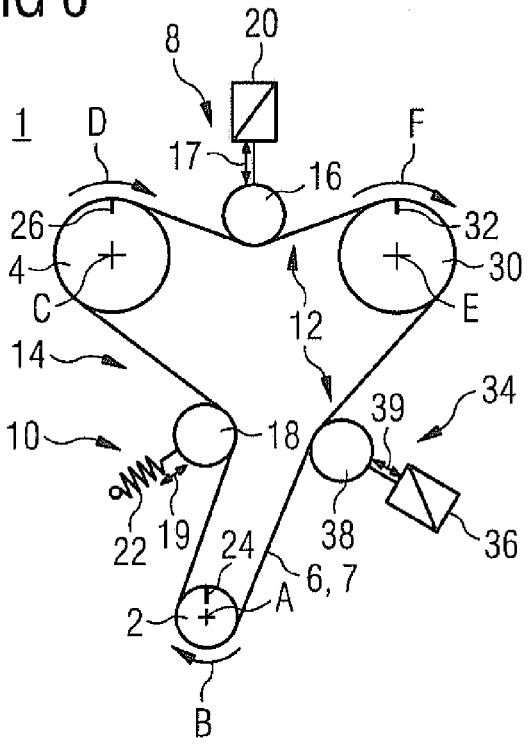
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FIG 7

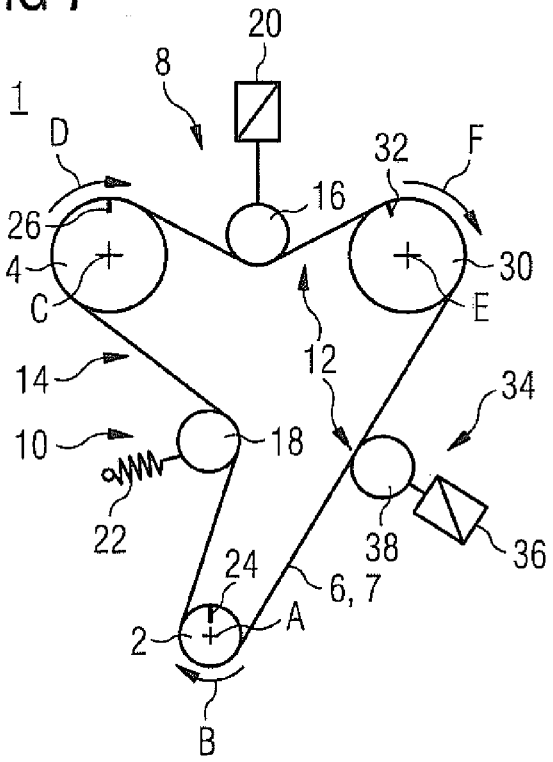
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FIG 8

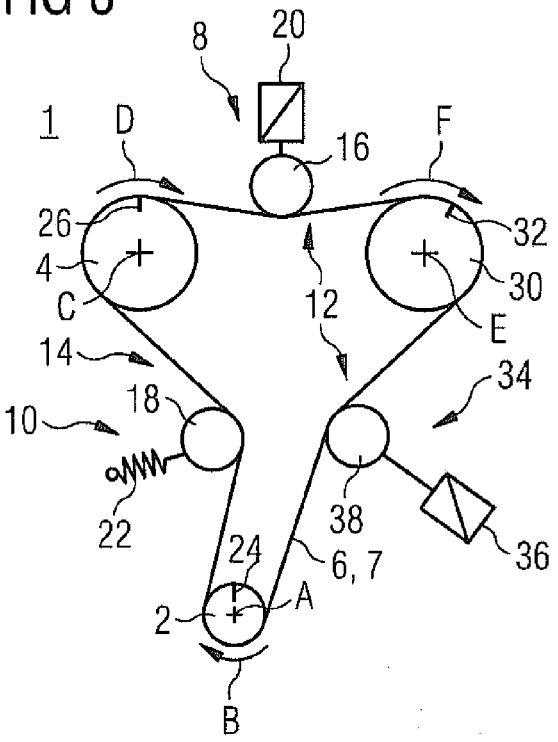
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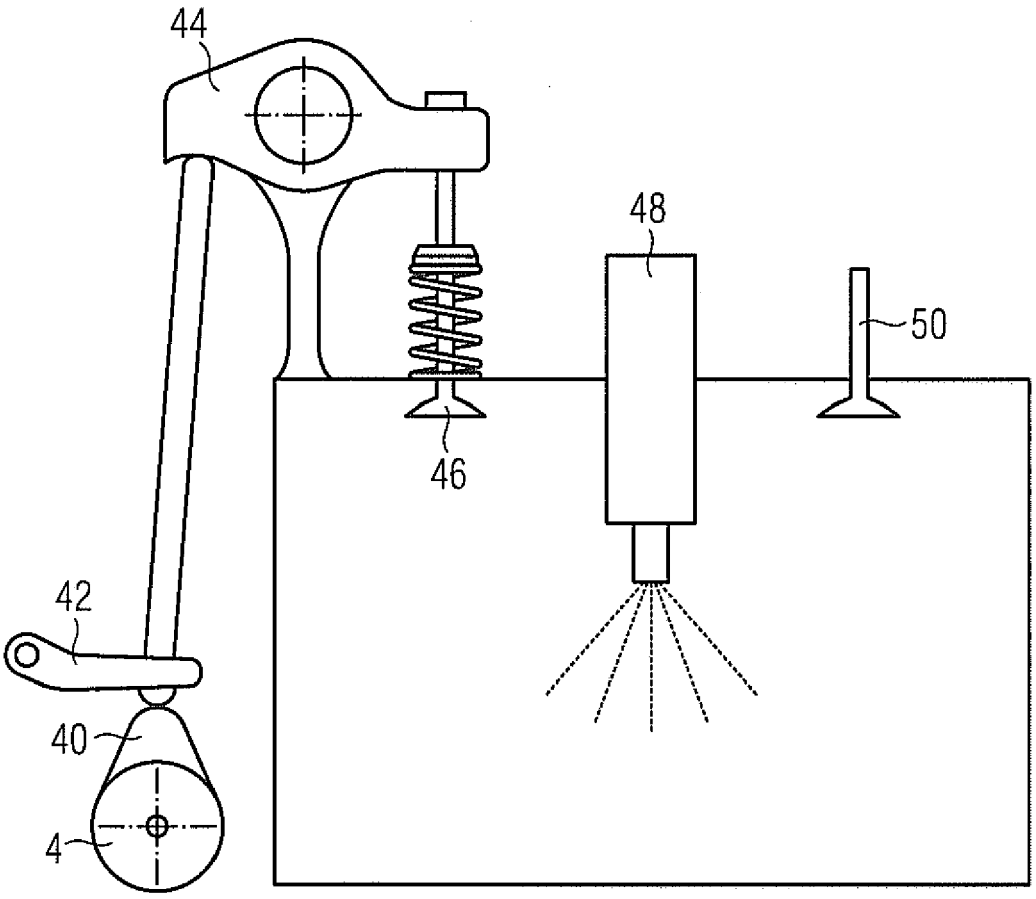
FIG 9



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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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