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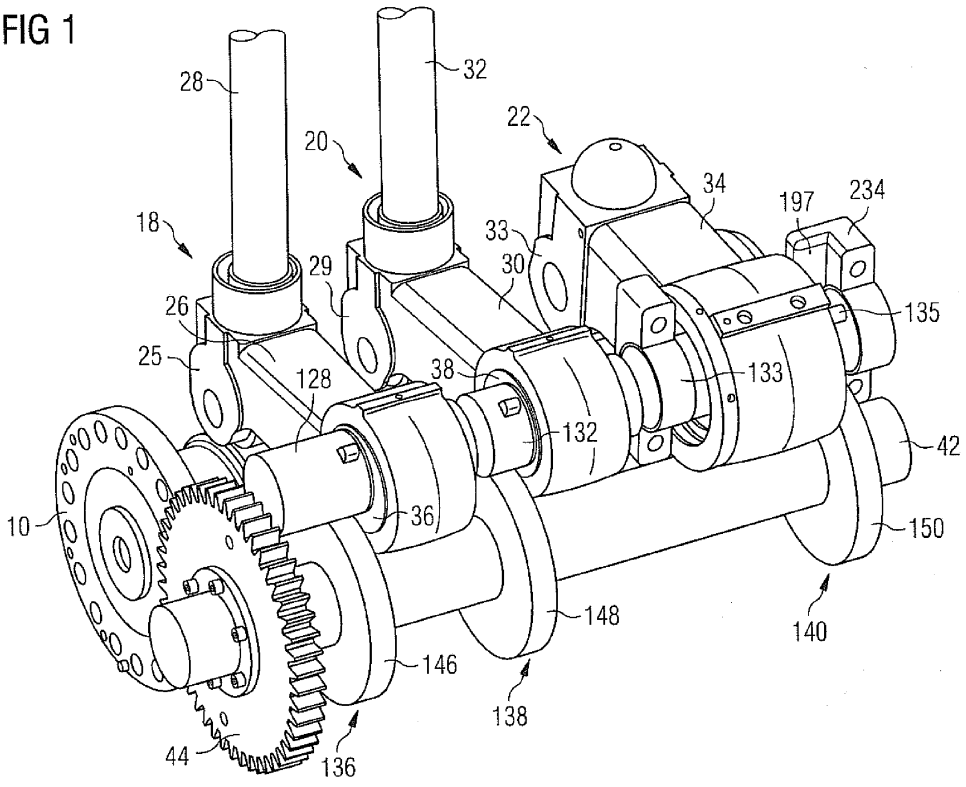
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(54) Method and device for controlling the operation of an internal combustion engine

(57) In an internal combustion engine, an inlet valve timing, an exhaust valve timing and a fuel injection timing are controlled independently from one another by appropriate rotation of a shaft (42). An inlet valve operating lever support (126), an outlet valve operating lever support (130) and a fuel injection operating lever support (134) are rotationally supported by separate rotatable shafts, each rotatable shaft being provided with a corresponding eccentric (36, 38, 40) for supporting an associated operating lever. The shaft (42) is configured to engage at least two of the operating lever supports at different rotational positions to adjust the same. Accordingly, at least one of an inlet valve timing, an exhaust valve timing and an injection timing may be adjusted by the shaft (42) while at least one other remains stationary.

FIG 1



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Description

Technical Field

[0001] The present disclosure generally relates to a method and device for controlling the operation of an internal combustion engine. Such an internal combustion engine may be equipped with an exhaust after treatment system and/or may be charged via an exhaust gas turbocharger. In particular, but not exclusively, large internal combustion engines configured to bum diesel and/or gas as used, for example, on ships, with heavy road vehicles and construction vehicles, or in power plants may be controlled according to the present disclosure.

Background

[0002] Various technologies for adjusting the opening and closing of inlet valves and outlet valves are known, for example, from EP 0 560 126 A1, GB 969,297, US 5,713,335 A, US 5,666,913 A, JP 2006-153009 A, DE 33 13 313 C2, DE 10 2004 057 438 A1, US 2009/0235886 A1, JP 11-36833 A, DE 32 13 565 A1, US 6,431,134 B1, EP 1 273 795 A1, EP 1 477 638 A1, and DE 10 359 087 B3.

[0003] EP 2 136 054 Al shows a device for controlling the operation of a diesel engine equipped with a rotatable shaft provided with three eccentrics. Each eccentric supports an operating lever. A first eccentric supports an inlet valve operating lever formed, for example, as an oscillating arm, which may trace a stroke of an inlet cam via, for example, a roll supported thereon, and may transmit it to the inlet valve via, for example, an inlet valve operating lifter, in order to operate the inlet valve. In a similar manner, a second eccentric supports an outlet valve operating lever, which may trace the stroke of an outlet cam via, for example, a roll supported thereon, and may transmit it to an outlet valve operating lifter. A stroke of a fuel pump cam may be traced by, for example, a roll arranged at the end of a pump operating lever and transmitted to a pump piston via, for example, a pressure spring. The pump operating lever is supported on the third eccentric. The eccentrics may be formed integrally with the rotatable shaft. The eccentricities of the preferably circular cylindrical circumferential surfaces of the eccentrics relative to the axis of the rotatable shaft, as well as the relative position of the eccentricities relative to the rotational position of the shaft may be selected individually according to the respective requirements. An actuator and gear wheels form an adjusting device. At stationary operation, the diesel engine is operated at a load greater than 25 % of the full load with two valve lifting curves, i.e. in the Miller cycle. At loads below 25 % of the full load, the shaft is twisted, so that the diesel engine is operated with two different valve lifting curves. This technology is also known as flexible camshaft technology (FCT).

[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] Generally, the present disclosure relates to a device for controlling the operation of an internal combustion engine. Exemplary internal combustion engines may be, for example, an internal combustion engine operable in a low load liquid fuel mode and a high load liquid fuel mode. Other exemplary internal combustion engines may be dual fuel engines operable in a liquid fuel mode and a gaseous fuel mode (also referred to as gas mode), or gas engines. A rotatable shaft configured to engage with first to third eccentrics may be rotatable by an adjusting device. Three different rotational positions of the shaft in combination with individual designs and arrangements of the first, second and third eccentrics may result in respective different appropriate opening and closing timings of inlet and outlet valves, and an adjusted injection of fuel, for example, liquid fuel during a low load liquid fuel mode and a high load liquid fuel mode.

[0006] In one aspect of the present disclosure, a device for controlling the operation of an internal combustion engine comprises an inlet valve operating lever support rotationally supported, the inlet valve operating lever support being provided with a first eccentric configured to support an inlet valve operating lever for controlling an inlet valve, an outlet valve operating lever support rotationally supported, the outlet valve operating lever support being provided with a second eccentric configured to support an outlet valve operating lever for controlling an outlet valve, and a fuel injection operating lever support rotationally supported, the fuel injection operating lever support being provided with a third eccentric configured to support a fuel injection operating lever for controlling a fuel injection. The device further comprises a shaft rotationally supported, the shaft being provided with a first engagement portion, a second engagement portion and a third engagement portion, the first engagement portion being configured to engage with the inlet valve operating lever support to rotate the same between a first inlet valve operating position and a second inlet valve operating position, the second engagement portion being configured to engage with the outlet valve operating lever support to rotate the same between a first outlet valve operating position and a second outlet valve operating position, and the third engagement portion being configured to engage with the fuel injection operating lever support to rotate the same between a first fuel injection operating position and a second fuel injection operating position. At least two of the inlet valve operating lever support, the outlet valve operating lever support and the fuel injection operating lever support are configured to rotate independent from each other, the at least two of the inlet valve operating lever support, the outlet valve operating lever support and the fuel injection operating lever support and the associated engagement portions of the shaft

being configured to engage with each other at different rotational positions of the shaft.

[0007] In another aspect of the present disclosure, a method for controlling the operation of an internal combustion engine, the internal combustion engine comprising an inlet valve operating lever support rotationally supported, the inlet valve operating lever support being provided with a first eccentric configured to support an inlet valve operating lever for controlling an inlet valve, an outlet valve operating lever support rotationally supported, the outlet valve operating lever support being provided with a second eccentric configured to support an outlet valve operating lever for controlling an outlet valve, a fuel injection operating lever support rotationally supported, the fuel injection operating lever support being provided with a third eccentric configured to support a fuel injection operating lever for controlling a fuel injection, and a shaft rotationally supported, the shaft being configured to engage with the inlet valve operating lever support, the outlet valve operating lever support, and the fuel injection operating lever support to rotate the same, comprises the steps of rotating the shaft from a first rotational position to a second rotational position to rotate at least one first operating lever support while at least one second operating lever support remains stationary, and rotating the shaft from the second rotational position to a third rotational position to rotate the at least one second operating lever support.

[0008] Dual fuel engine may mean any type of internal combustion engine configured to bum both liquid fuels, for example, diesel, heavy fuel oil (HFO) or marine diesel oil (MDO), and gaseous fuels.

[0009] According to the present disclosure, "late" may mean inter alia that the inlet valve opening begins later than the inlet valve opening in the high load liquid fuel mode. "Early" may mean inter alia that the injection of liquid fuel begins earlier than in the high load liquid fuel mode.

[0010] It has to be noted that the terms "gas fuel mode", "gas mode" and "gaseous fuel mode" may be used herein for the same kind of operation mode of the internal combustion engine. All these terms may refer to that kind of operation mode of the internal combustion engine in which the internal combustion engine bums a gaseous fuel such as, for example, gas of any gas quality, particularly non-pipeline quality gas as associated with gas in oil fields. In this respect, it is to be understood that, even in the gas mode, a pilot injection system may inject a very small amount of liquid fuel when a dual fuel engine is operating in gas mode. The pilot injection system injects a small amount of liquid fuel to ignite a gas/air mixture. Such pilot injection systems are well-known in the art and common in dual fuel engines. A conventional injection system is used when the dual fuel engine runs on liquid fuel such as heavy fuel oil or diesel oil. If a stop of liquid fuel is mentioned herein in respect to a gas mode, the stop of supply of liquid fuel to the conventional injection system is meant, not to the pilot injection system.

[0011] It is to be understood that any reference to an inlet valve, an outlet valve or a fuel injection device, for example, a fuel pump, does not limit the present disclosure to one single valve or pump. To the contrary, one or more inlet and outlet valves or one ore more fuel pumps may be controlled by one ore more eccentrics.

[0012] Furthermore, it is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not limiting the disclosure. Other features and aspects of this disclosure will be apparent to the skilled person based upon the following description, the accompanying drawings and the attached claims.

Brief Description of the Drawings

[0013] 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:

[0014] Fig. 1 shows a partial perspective view of a control device according to the present disclosure;

[0015] Fig. 2 shows a detailed view of the control device of Fig. 1;

[0016] Fig. 3 shows two schematic cross-sectional views of the control device of Fig. 1;

[0017] Fig. 4 shows two other schematic cross-sectional views of the control device of Fig. 1;

[0018] Fig. 5 shows another schematic cross-sectional view of the control device of Fig. 1;

[0019] Figs. 6A-6C each show three different cross-sectional views of the control device of Fig. 1 for use with a dual fuel engine; and

[0020] Figs. 7A-7C each show three schematic cross-sectional views of the control device of Fig. 1 for use with a diesel engine having an exhaust after treatment system.

Detailed Description

[0021] According to Fig. 1, a not illustrated internal combustion engine, charged via an exhaust gas turbocharger, includes, for example, a camshaft 10 which is preferably formed integrally with several cams, for example, an inlet cam 12, an outlet cam 14 and an injection cam 16 (shown in Fig. 2).

[0022] Inlet cam 12 may operate an inlet valve that is arranged in an inlet of a combustion chamber of a cylinder of the internal combustion engine and operated via, for example, an inlet valve operating arrangement 18. Outlet cam 14 may operate an outlet valve arranged in an outlet of the combustion chamber via, for example, an outlet valve operating arrangement 20. Injection cam 16 may operate an injection device, for example, a pump piston (not shown) of an injection pump via, for example, a pump operating arrangement 22.

[0023] Inlet valve operating arrangement 18 comprises

an inlet valve operating lever 26 formed, for example, as an oscillating arm, which may trace the stroke of inlet cam 12 via, for example, a roll 25 supported thereon, and transmit it to the inlet valve via, for example, an inlet valve operating lifter 28 in order to operate said inlet valve.

[0024] In a similar manner, outlet valve operating arrangement 20 is provided with an outlet valve operating lever 30, which may trace the stroke of outlet cam 14 via, for example, a roll 29 supported thereon, and transmit it to an outlet valve operating lifter 32.

[0025] The stroke of injection cam 16 may be traced by, for example, a roll 33 arranged at the end of a fuel injection operating lever 34 and transmitted to the injection device.

[0026] At their ends facing away from tracing rolls 25, 29, 33, operating levers 26, 30 and 34 are supported on eccentric disks 36, 38 and 40, which are preferably formed integrally with separate rotatable shafts 128, 132, 133 to form rotatable operating lever supports that may be rotatably supported on an engine housing (not shown). The eccentricities of the preferably circular cylindrical circumferential surfaces of the eccentric disks 36, 38, 40 relative to the axis of the corresponding shaft, as well as the relative position of the eccentricities relative to the rotational position of the corresponding shaft, may be selected individually according to the respective requirements outlined herein.

[0027] An inlet valve operating lever support 126 includes shaft 128 and eccentric 36 and is configured to support inlet valve operating lever 26 for controlling the inlet valve.

[0028] An outlet valve operating lever support 130 includes shaft 132 and eccentric 38 and is configured to support outlet valve operating lever 30 for controlling the outlet valve.

[0029] A fuel injection operating lever support 134 includes shaft 133 and eccentric 40 and is configured to support fuel injection operating lever 34 for controlling the fuel injection.

[0030] A rotatable shaft 42 that is supported, for example, on the engine housing extends adjacent to operating lever supports 126-134. Shaft 42 is provided with a first engagement portion 136 configured to engage with inlet valve operating lever support 126, in particular, shaft 128, to rotate the same between a first inlet valve operating position and a second inlet valve operating position. Further, shaft 42 is provided with a second engagement portion 138 configured to engage with outlet valve operating lever support 130, in particular, shaft 132, to rotate the same between a first outlet valve operating position and a second outlet valve operating position. Shaft 42 is also provided with a third engagement portion 140 configured to engage with fuel injection operating lever support 134, in particular, shaft 133, to rotate the same between a first fuel injection operating position and a second fuel injection operating position. First engagement portion 136, second engagement portion 138 and third engagement portion 140 are spaced apart from each other in a longitudinal direction of shaft 42, i.e. first engagement portion 136 is provided adjacent to inlet valve operating lever support 126, second engagement portion 138 is provided adjacent to outlet valve operating lever support 130, and third engagement portion 140 is provided adjacent to fuel injection operating lever support 134. As will be described in more detail below, at least two of first engagement portion 136, second engagement portion 138 and third engagement portion 140 are offset from one another in a circumferential direction of shaft 42 to engage with the associated lever supports at different rotational positions of shaft 42.

[0031] In order to adjust the rotational position of shaft 42, shaft 42 may be connected, for example, torsionally stiff, to a gearwheel 44 or any other applicable element meshing with, for example, teeth of a segmental gearwheel which may be adjustable via, for example, an actuator unit (not shown). The actuator unit together with the segmental gearwheel and gearwheel 44 may form an adjusting device. A hydraulic or pneumatic cylinder may be used as a longitudinally adjustable element. Also, a linear motor or any other technical element may be suitable to rotate shaft 42 in an appropriate manner, for example, via a rack and pinion mechanism or the like.

[0032] In some exemplary embodiments, an actuator configured to adjust shaft 42 in at least three different rotational positions may be used. In other exemplary embodiments, an actuator configured to continuously vary the rotational angle of shaft 42 may be used for adjusting shaft 42. In yet other embodiments, an actuator or a combination of actuators configured to continuously vary the rotational angle of shaft 42 in a first range, and discretely adjust the rotational angle of shaft 42 in a second range may be used.

[0033] For controlling the actuator unit, an electronic control device may be provided, which preferably comprises a microprocessor with appropriate program and data memories, and which may be provided with several outputs, at least one of said outputs being connected to the actuator unit. The electronic control device is preferably provided with several inputs, one of said inputs being connected with, for example, a load adjusting element, by means of which the load of the internal combustion engine is mechanically selectable or adjustable.

[0034] Referring now to Fig. 2, the control device according to the present disclosure is shown in more detail. In particular, Fig. 2 shows engagement portions 136, 138 formed on shaft 42 and the configuration of operating lever supports 126-134 in more detail. It should be appreciated that engagement portion 140 has a configuration similar to engagement portions 136, 138.

[0035] As described above, each operating lever support may be formed with a separate rotatable shaft which may be supported by the internal combustion engine. Each operating lever support may be supported in a separate support structure, for example, a housing or the like. For the sake of clarity, only part of a housing 234 for fuel injection operating lever support 134 is shown in Figs.

1 and 2. It should be appreciated, however, that corresponding support structures are also provided for inlet valve operating lever support 126 and outlet valve operating lever support 130.

[0036] First engagement portion 136 associated with inlet valve operating lever support 126 may be formed as a flange 146 integrally formed with shaft 42. On an outer circumferential surface of flange 146, a nose 147 may be provided. Nose 147 may be configured to engage with a corresponding groove 157 formed in the shaft of inlet valve operating lever support 126. In some embodiments, a biasing mechanism, for example, one or more biasing springs (not shown), may be provided to bias operating lever support 126 (and, in a similar manner, operating lever supports 130, 134) against shaft 42 for reliable engagement of nose 147 and groove 157 during rotation of shaft 42. When nose 147 comes into engagement with groove 157, rotation of shaft 42 will result in rotation of inlet valve operating lever support 126 and eccentric 36 associated with the same. According to the position of eccentric 36, inlet valve operating lever 26 may be adjusted to different orientations resulting in different opening and closing timings of the associated inlet valve.

[0037] Second engagement portion 138 includes a second flange 148 and a second nose 149 formed on an outer peripheral surface of second flange 148. Second nose 149 is configured to engage with a corresponding groove 159 formed in outlet valve operating lever support 130. The configuration of second engagement portion 138 and outlet valve operating lever support 130 is similar to the configuration of first engagement portion 136 and inlet valve operating lever support 126, such that a detailed description will be omitted.

[0038] Although not shown in Fig. 2, it will be appreciated that third engagement portion 150 associated with fuel injection operating lever support 134 is configured in a similar manner, including a third flange 150 (see Fig. 1) and a third nose 151 formed on an outer peripheral surface of third flange 150 and configured for engagement with a corresponding groove 161 formed in shaft 133 of fuel injection operating lever support 134 (see Figs. 6A-7C).

[0039] Rotation of inlet valve operating lever support 126, outlet valve operating lever support 130 and fuel injection operating lever support 134 may be limited to a rotation between a first limiting position and a second limiting position, respectively. A corresponding stop mechanism for each operating lever support may, for example, include noses 127, 131, 135 formed on the shafts of the corresponding operating lever supports. Each of noses 127, 131, 135 may be configured to abut against mechanical stops 187, 189, 191, 193, 195, 197 to limit the movement of the associated operating lever support. For example, nose 135 of fuel injection operating lever support 134 may be guided in a notch or groove of housing 234 supporting fuel injection operating lever support 134 and may abut against stop 197 (see Fig. 1). The stop mechanisms for the other operating lever supports may have a similar configuration, as will be described in more detail below. It will be appreciated that, in other exemplary embodiments of the present disclosure, different stop mechanisms may be provided for each of the three operating lever supports. In the same manner, one or more brake mechanisms (not shown) may be provided for operating lever supports 126, 130, 134 for maintaining the respective operating lever supports in their respective limiting positions when they are not engaged by shaft 42, for example, via friction.

[0040] An operation of the control device shown in Figs. 1 and 2 in accordance with an exemplary embodiment of the present disclosure is described with reference to Figs. 3-5. For the sake of illustrating the underlined principle, an adjustment of inlet valve operating lever support 126 resulting in different inlet valve timings is described in Figs. 3-5. It will be appreciated, however, that the same principle applies to the operation of outlet valve operating lever support 130 and fuel injection operating lever support 134.

[0041] As shown in Fig. 3, shaft 42 and inlet valve operating lever support 126 may be configured such that, when shaft 42 is in a position in which nose 147 is not engaged with groove 157 and is disposed on one side of shaft 128 of inlet valve operating lever support 126, inlet valve operating lever support 126 and the corresponding eccentric 36 are in a first position, in particular, a first limiting position, in which nose 127 abuts against a first stop 189.

[0042] When shaft 42 is rotated counter clockwise, nose 147 is brought into engagement with groove 157. Accordingly, inlet valve operating lever support 126 is rotated clockwise. The clockwise rotation of inlet valve operating lever support 126 may be stopped by nose 147 abutting against a second stop 187. Accordingly, inlet valve operating lever support 126 may be rotated from the first position shown on the left of Fig. 3 to the second position shown on the right of Fig. 3 by rotation of shaft 42. This results in that eccentric 36 is also rotated clockwise, and inlet valve operating lever 26 (not shown) is displaced to the right in Fig. 3, resulting in an adjusted inlet valve timing.

[0043] Upon further rotation of shaft 42, as shown in Fig. 4, inlet valve operating lever support 126 will remain in the second position, i.e. a second limiting position, and nose 147 will be out of engagement with groove 157. Accordingly, the position of inlet valve operating lever support 126 will remain stationary while shaft 42 continues to rotate. In this manner, as will be described in more detail below, it is possible to individually rotate each of inlet valve operating lever support 126, outlet valve operating lever support 130 and fuel injection operating lever support 134 when noses 147, 149, 151 are disposed at different positions along the circumferential direction of shaft 42. For example, shaft 42 could be configured such that, when shaft 42 is in the position shown on the right of Fig. 4, nose 151 is in engagement with corre-

sponding groove 161 formed in fuel injection operating lever support 134. Accordingly, the timing of the fuel pump could be adjusted independent from the timing of, for example, the inlet valve.

[0044] It will be appreciated that, as shown in Fig. 5, when shaft 42 is rotated to a position in which nose 147 is in engagement with groove 157 and nose 127 is in an intermediate position between stops 189 and 187, the position of inlet valve operating lever support 126 and the corresponding eccentric 36 may be continuously adjusted when shaft 42 is rotated. As will be described in more detail below, when an actuator, which is configured to continuously vary the rotational angle of shaft 42, is used, the position of inlet valve operating lever support 126 and the corresponding valve timing may be continuously varied while nose 127 is in engagement with groove 157. For example, in case shaft 42 is configured such that, when nose 147 is in engagement with groove 157, noses 149 and 151 are not in engagement with corresponding grooves 159, 161, the timing of the inlet valve may be continuously varied without changing the timing of the outlet valve and the fuel injection. It will be readily apparent to the skilled person that using appropriate configurations for shaft 42 and operating lever supports 126, 130, 134 allows many different combinations for individually adjusting the timing of the corresponding valves and the fuel injection.

[0045] While engagement portions 136, 138, 140 have been described herein as flanges formed on shaft 42, each flange being provided with a corresponding nose for engaging a groove of the associated operating lever support, many different configurations may be used for the corresponding engagement portions. For example, instead of the noses 147-151 being provided on shaft 42, noses could also be provided on the shafts of operating lever supports 126-134, with corresponding grooves being formed in shaft 42 at appropriate positions. In this configuration, biasing springs may also be provided to bias operating lever supports and shaft 42 against each other in an appropriate manner. Further, while in some exemplary embodiments flanges 146, 148, 150 may be annular, in other embodiments, flanges 146, 148, 150 may have a different configuration or may be omitted.

[0046] Further, it will be appreciated that many different configurations of operating lever supports 126-134 and shaft 42 are possible without departing from the scope of the present disclosure. For example, only two of the operating lever supports may be provided separately to rotate independent from each other, i.e. two of operating lever supports 126-134 may be coupled to each other to rotate together. Further, while in the exemplary embodiments described herein at least two of engagement portions 136-140 are offset from each other in the circumferential direction of shaft 42, in other embodiments, engagement portions 136-140 may be identical and operating lever supports 126-134 may be arranged differently or have different configurations to result in the engagement with engagement portions 136-140 at different rotational angles of shaft 42. For example, two of operating lever supports 126-134 may be offset from each other.

Industrial Applicability

[0047] It will be readily appreciated that a control device according to the present disclosure may have many different configurations, depending on the desired application.

[0048] A first exemplary application of the teaching of the present disclosure will be described in the following with respect to Figs. 6A-6C.

[0049] In this exemplary application, the control device according to the present disclosure may be applied to a dual fuel engine. Such dual fuel engines may need at least three sets of combinations for the valve timings and the timing of a main injection of liquid fuel, for example, diesel fuel, provided by a fuel pump.

[0050] For example, shaft 42 and operating lever supports 126, 130, 134 may be configured such that, when shaft 42 is in a first position as shown in Fig. 6A, noses 147, 149, 151 are out of engagement with grooves 157, 159, 161 and are all disposed on one side of each operating lever support shaft. Nose 151 may be offset from noses 147, 149. Each of operating lever supports 126, 130, 134 may be in a first limiting position. The corresponding eccentrics 36, 38, 40 may be configured such that, in the first limiting position, the inlet valve is operated with an early inlet valve timing, the exhaust valve is operated with a late exhaust valve timing, and the fuel pump is operated with a "normal" injection timing corresponding to a high load diesel mode with a strong Miller cycle.

[0051] When the dual fuel engine is to be operated in the gas mode, shaft 42 is rotated counter clockwise to the position shown in Fig. 6B. As nose 151 associated with fuel injection operating lever support 134 is offset from noses 147, 149, when shaft 42 is rotated counter clockwise to a second position, noses 147, 149 are brought into engagement with grooves 157, 159 and rotate inlet valve operating lever support 126 and outlet valve operating lever support 130 in a clockwise direction, while nose 151 is not brought into engagement with groove 161 and fuel injection operating lever 34 remains stationary.

[0052] Accordingly, with the exemplary configuration described above, only the timings of the inlet valve and the exhaust valve are adjusted when the shaft 42 is rotated. In the exemplary dual fuel engine application described herein, the second limiting position of inlet valve operating lever support 126 may correspond to a late inlet valve timing, and the second limiting position of outlet valve operating lever support 130 may correspond to an early exhaust valve timing.

[0053] Upon further rotation of shaft 42, as shown in Fig. 6C, nose 151 is brought into engagement with groove 161 and causes fuel injection operating lever support 134 to rotate clockwise. Accordingly, fuel injection operating lever support and eccentric 40 are rotated to the second

limiting position of fuel injection operating lever support 134 while inlet valve operating lever support 126 and outlet valve operating lever support 130 remain in their respective positions. Accordingly, the injection timing of the main injection by the fuel pump is adjusted while the valve timings remain the same. In the exemplary dual fuel application described herein, the second limiting position of fuel injection operating lever support 134 may result in an early injection timing of the fuel pump. Accordingly, the configuration shown in Fig. 6C may be used for a low load diesel mode of the dual fuel engine with nearly no Miller cycle, a small valve overlap and an early injection timing.

[0054] Accordingly, with the control device disclosed herein, it is possible to provide at least three different configurations for the operation of a dual fuel engine in a high load diesel fuel mode, a low load diesel fuel mode and a gas mode by rotating shaft 42 to one of three different positions. In particular, transitions from the gas mode to one of the low load diesel fuel mode and the high load diesel fuel mode may be effected by rotation between the position of shaft 42 shown in Fig. 6B and the positions of shaft 42 shown in Figs. 6A, 6C, respectively.

[0055] In a second exemplary application of the present disclosure, the control device according to the present disclosure may be used with a diesel engine with an exhaust after treatment system such as an SCR system. Such a diesel engine generally requires two configurations, a low load diesel fuel mode and a high load diesel fuel mode. However, in addition, in case the diesel engine is operated in an emission controlled area, additional control may be required for the timing of the exhaust valve. This additional control may be a load dependent control.

[0056] Accordingly, shaft 42 and operating lever supports 126, 130, 134 may be configured such that, when shaft 42 is in a first position, as shown in Fig. 7A, inlet valve operating lever support 126 is in its first limiting position, outlet valve operating lever support 130 is in its second limiting position, and fuel injection operating lever support 134 is in its first limiting position. In the exemplary embodiment described herein, the first limiting position of inlet valve operating lever support 126 may correspond to an early inlet valve timing, the second limiting position of outlet valve operating lever support 130 may correspond to a late exhaust valve timing, and the first limiting position of fuel injection operating lever support 134 may correspond to a "normal" injection timing of the fuel pump, for example, in the high load diesel fuel mode.

[0057] When the diesel engine is to be operated in the low load diesel fuel mode, shaft 42 may be turned counter clockwise. Noses 147, 149, 151 may be arranged on shaft 42 such that, when shaft 42 is rotated counter clockwise from the first position shown in Fig. 7A to the second position shown in Fig. 7B, noses 147, 151 are brought into engagement with grooves 157, 161, while nose 149 is not in engagement with groove 159 formed on outlet valve operating lever support 130. Accordingly, rotation of shaft 42 to the position shown in Fig. 7B may result in the inlet valve timing being adjusted from an early inlet valve timing to a late inlet valve timing and the injection timing being adjusted from a "normal" injection timing to an early injection timing, while the late exhaust valve timing is not adjusted. The configuration shown in Fig. 7B may correspond to the low load diesel fuel mode with nearly no Miller cycle, a smaller valve overlap and an early injection timing.

[0058] On the other hand, when the diesel engine is to be operated in an emission controlled area, a strong Miller cycle and a "normal" injection timing are required in the high load diesel fuel mode, while a variable timing is required for the exhaust valve. This may be achieved with the control device according to the present disclosure as shown in Fig. 7C.

[0059] Namely, when an emission controlled area is entered and the diesel engine is to be operated in a corresponding emission controlled operating mode, shaft 42 may be rotated clockwise from the first position shown in Fig. 7A to a third position shown in Fig. 7C. Shaft 42 and operating lever support 126, 130, 134 may be configured such that, upon rotation of shaft 42 from the position shown in Fig. 7A to the position shown in Fig. 7C, nose 149 is brought into engagement with groove 159 formed on outlet valve operating lever support 130. However, noses 147, 151 may be arranged on shaft 42 such that, at the same time, noses 147, 151 do not come into engagement with grooves 157, 161. Accordingly, in the position of shaft 42 shown in Fig. 7C, it is possible to continuously vary the timing of the outlet valve while maintaining the early inlet valve timing and the "normal" injection timing of the high load diesel fuel mode shown in Fig. 7A.

[0060] While exemplary applications of the control device according to the present disclosure have been described above with reference to a dual fuel engine and a diesel engine with exhaust after treatment, it will be appreciated that the control device according to the present disclosure may be applied to many different internal combustion engines, for example, gas engines, without departing from the scope of the present disclosure. Further it should be appreciated that any appropriate fuel injection device such as a fuel pump or the like may be used for injecting liquid fuel or gaseous fuel in accordance with the present disclosure.

[0061] Herein, an internal combustion engine may be any kind of large internal combustion engine having an output range of 1,000 kW or more. Internal combustion engines as disclosed herein may be suitable for operation with heavy fuel oil (HFO), marine diesel oil (MDO), diesel oil (DO) and gas. Further, an internal combustion engine according to the present disclosure may include any number of cylinders in any known cylinder configuration. Shaft 42 may be embodied as a single shaft for a number of cylinders of the internal combustion engine, or a separate shaft 42 may be provided for each cylinder of the

internal combustion engine.

[0062] Although the preferred embodiments of this disclosure have been described herein, improvements and modifications may be incorporated without departing from the scope of the appended claims.

Claims

1. A device for controlling the operation of an internal combustion engine, comprising:

an inlet valve operating lever support (126) rotationally supported, the inlet valve operating lever support (126) being provided with a first eccentric (36) configured to support an inlet valve operating lever (26) for controlling an inlet valve;
an outlet valve operating lever support (130) rotationally supported, the outlet valve operating lever support (130) being provided with a second eccentric (38) configured to support an outlet valve operating lever (30) for controlling an outlet valve;
a fuel injection operating lever support (134) rotationally supported, the fuel injection operating lever support (134) being provided with a third eccentric (40) configured to support a fuel injection operating lever (34) for controlling a fuel injection device; and
a shaft (42) rotationally supported, the shaft (42) being provided with a first engagement portion (136), a second engagement portion (138) and a third engagement portion (140), the first engagement portion (136) being configured to engage with the inlet valve operating lever support (126) to rotate the same between a first inlet valve operating position and a second inlet valve operating position, the second engagement portion (138) being configured to engage with the outlet valve operating lever support (130) to rotate the same between a first outlet valve operating position and a second outlet valve operating position, and the third engagement portion (140) being configured to engage with the fuel injection operating lever support (134) to rotate the same between a first fuel injection operating position and a second fuel injection operating position,
at least two of the inlet valve operating lever support (126), the outlet valve operating lever support (130) and the fuel injection operating lever support (134) being configured to rotate independent from each other,
the at least two of the inlet valve operating lever support (126), the outlet valve operating lever support (130) and the fuel injection operating lever support (134), and the associated engagement portions of the shaft (42) being configured to engage with each other at different rotational positions of the shaft (42).

2. The device of claim 1, wherein each of the first engagement portion (136), the second engagement portion (138) and the third engagement portion (140) includes a flange (146, 148, 150) and a nose (147, 149, 151) or groove provided on the flange (146, 148, 150), the flanges (146, 148, 150) being spaced apart from each other in a longitudinal direction of the shaft (42), at least two of the noses (147, 149, 151) or grooves being offset from each other in a circumferential direction of the shaft (42) and being configured to engage with a corresponding groove (157, 159, 161) or nose provided on the associated operating lever support to rotate the same.

3. The device of claim 1 or 2, wherein the inlet valve operating lever support (126) is rotationally supported via a first separate shaft (128), the outlet valve operating lever support (130) is rotationally supported via a second separate shaft (132), and the fuel injection operating lever support (134) is rotationally supported via a third separate shaft (133), the first separate shaft (128), the second separate shaft (132) and the third separate shaft (133) being coaxial with each other.

4. The device of any one of claims 1 to 3, further comprising at least one of a first stop mechanism (127, 187, 189) configured to limit the rotation of the inlet valve operating lever support (126) between the first inlet valve operating position and the second inlet valve operating position, a second stop mechanism (131, 191, 193) configured to limit the rotation of the outlet valve operating lever support (130) between the first outlet valve operating position and the second outlet valve operating position, and a third stop mechanism (135, 195, 197) configured to limit the rotation of the fuel injection operating lever support (134) between the first fuel injection operating position and the second fuel injection operating position.

5. The device of any one of claims 1 to 4, further comprising at least one of a first brake mechanism configured to maintain the inlet valve operating lever support (126) in the first inlet valve operating position and the second inlet valve operating position, a second brake mechanism configured to maintain the outlet valve operating lever support (130) in the first outlet valve operating position and the second outlet valve operating position, and a third brake mechanism configured to maintain the fuel injection operating lever support (134) in the first fuel injection operating position and the second fuel injection operating position.

6. The device of any one of claims 1 to 5, further com-

prising an adjusting device configured to adjust the shaft (42) in at least a first rotational position, a second rotational position different from the first rotational position, and a third rotational position different from the first rotational position and the second rotational position.

7. The device of claim 6, the first engagement portion (136), the second engagement portion (138), the third engagement portion (140), the inlet valve operating lever support (126), the outlet valve operating lever support (130) and the fuel injection operating lever support (134) being arranged such that, upon rotation of the shaft (42) from the first rotational position to the second rotational position, the inlet valve operating lever support (126) is rotated from the first inlet valve operating position to the second inlet valve operating position, the outlet valve operating lever support (130) is rotated from the first outlet valve operating position to the second outlet valve operating position, and the fuel injection operating lever support (134) remains in the second fuel injection operating position, and, upon rotation of the shaft (42) from the second rotational position to the third rotational position, the fuel injection operating lever support (134) is rotated from the first fuel injection operating position to the second fuel injection operating position while the inlet valve operating lever support (126) remains in the second inlet valve operating position and the outlet valve operating lever support (130) remains in the second outlet valve operating position.

8. The device of claim 6 or 7, the device being configured to control a dual fuel engine, the first rotational position corresponding to a high load liquid fuel operating mode, the second rotational position corresponding to a gaseous fuel operating mode, and the third rotational position corresponding to a low load liquid fuel mode of the dual fuel engine.

9. The device of claim 8, the inlet valve operating lever support (126) being designed such that, in the first inlet valve operating position, the associated inlet valve opens early, and, in the second inlet valve operating position, the associated inlet valve opens late, the outlet valve operating lever support (130) being designed such that, in the first outlet valve operating position, the associated outlet valve opens late, and, in the second outlet valve operating position, the associated outlet valve opens early, the fuel injection operating lever support (134) being designed such that, in the second fuel injection operating position, the fuel injection is controlled such that an injection of liquid fuel is performed early.

10. The device of claim 6, the first engagement portion (136), the second engagement portion (138), the third engagement portion (140), the inlet valve operating lever support (126), the outlet valve operating lever support (130) and the fuel injection operating lever support (134) being arranged such that, upon rotation of the shaft (42) from the first rotational position to the second rotational position, the inlet valve operating lever support (126) is rotated from the first inlet valve operating position to the second inlet valve operating position, the outlet valve operating lever support (130) remains in the first outlet valve operating position, and the fuel injection operating lever support (134) is rotated from the first fuel injection operating position to the second fuel injection operating position.

11. The device of claim 10, wherein, upon rotation of the shaft (42) from the second rotational position to the third rotational position, the outlet valve operating lever support (130) is rotated from the first outlet valve operating position to the second outlet valve operating position while the inlet valve operating lever support (126) remains in the second inlet valve operating position and the fuel injection operating lever support (134) remains in the second outlet valve operating position.

12. The device of any one of claims 6, 10 or 11, the device being configured to control an internal combustion engine having an exhaust treatment system, the first rotational position corresponding to a low load operating mode, the second rotational position corresponding to high load operating mode, and the third rotational position corresponding to an emission controlled operating mode of the internal combustion engine.

13. The device of claim 12, the inlet valve operating lever support (126) being designed such that, in the first inlet valve operating position, the associated inlet valve opens late, and, in the second inlet valve operating position, the associated inlet valve opens early, the outlet valve operating lever support (130) being designed such that, in the first outlet valve operating position, the associated outlet valve opens late, and, in the second outlet valve operating position, the associated outlet valve opens early, the fuel injection operating lever support (134) being designed such that, in the first fuel injection operating position, the fuel injection is controlled such that an injection of liquid fuel is performed earlier than in the second fuel injection operating position.

14. The device of any one of claims 6 to 13, wherein the adjusting device is configured to continuously vary the rotational position of the shaft (42) to adjust at least one of the inlet valve operating lever support (126), the outlet valve operating lever support (130) and the fuel injection operating lever support in a

continuum of positions between the first operating position and the second operating position.

15. A method for controlling the operation of an internal combustion engine, the internal combustion engine comprising an inlet valve operating lever support (126) rotationally supported, the inlet valve operating lever support (126) being provided with a first eccentric (36) configured to support an inlet valve operating lever (26) for controlling an inlet valve, an outlet valve operating lever support (130) rotationally supported, the outlet valve operating lever support (130) being provided with a second eccentric (38) configured to support an outlet valve operating lever (30) for controlling an outlet valve, a fuel injection operating lever support (134) rotationally supported, the fuel injection operating lever support (134) being provided with a third eccentric (40) configured to support a fuel injection operating lever (34) for controlling a fuel pump, and a shaft (42) rotationally supported, the shaft (42) being configured to engage with the inlet valve operating lever support (126), the outlet valve operating lever support (130), and the fuel injection operating lever support (134) to rotate the same, the method comprising the steps of:

rotating the shaft (42) from a first rotational position to a second rotational position to rotate at least one first operating lever support while at least one second operating lever support remains stationary, and
rotating the shaft (42) from the second rotational position to a third rotational position to rotate the at least one second operating lever support.

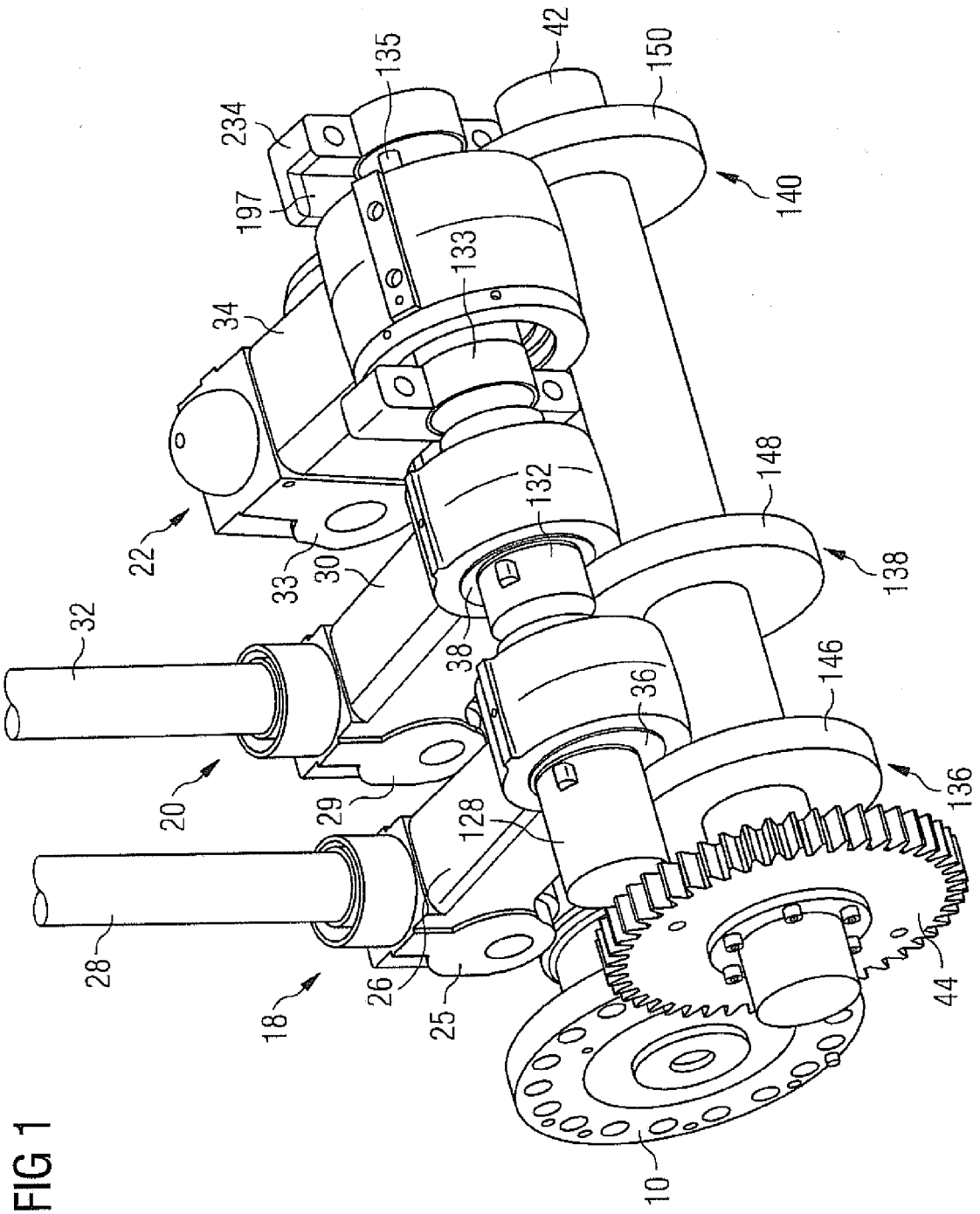

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FIG 1

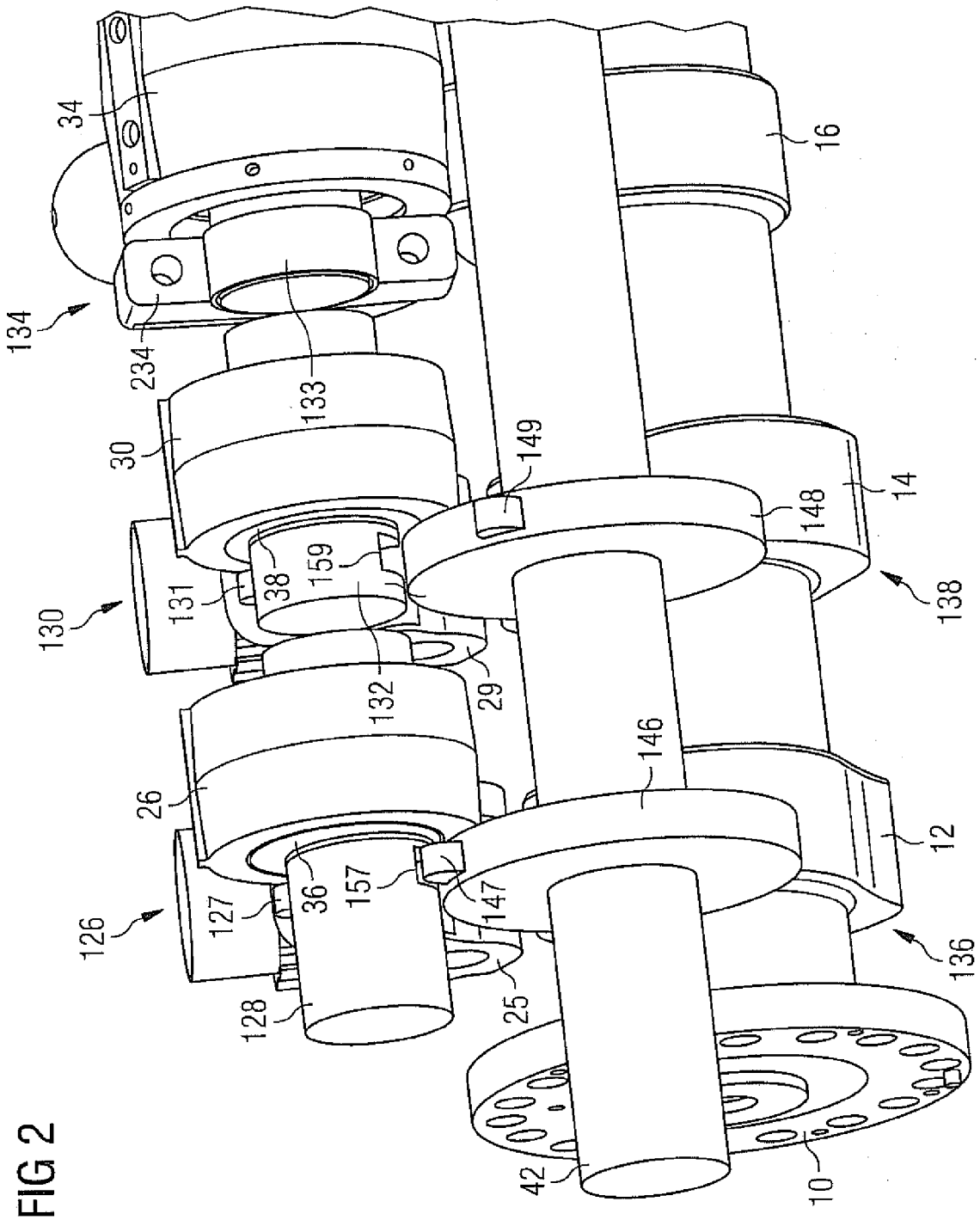

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FIG 2

FIG 3

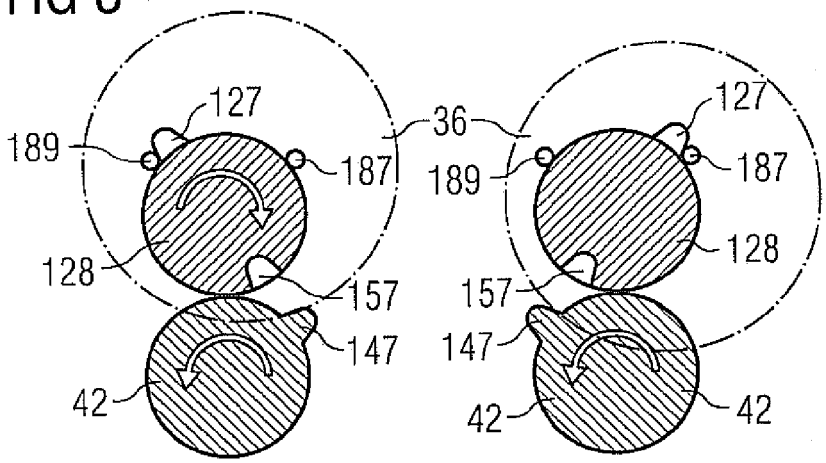


FIG 4

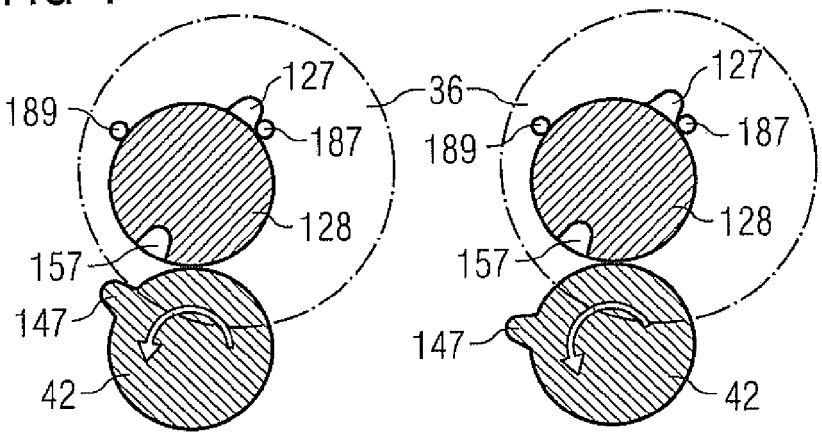


FIG 5

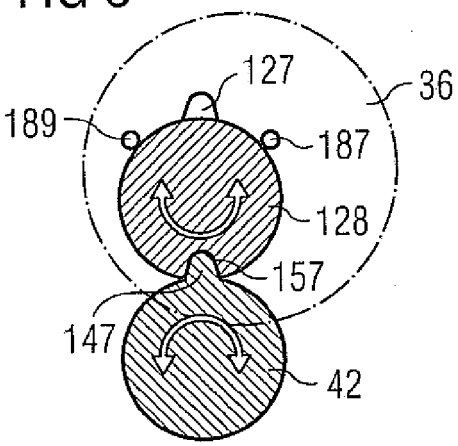


FIG 6A

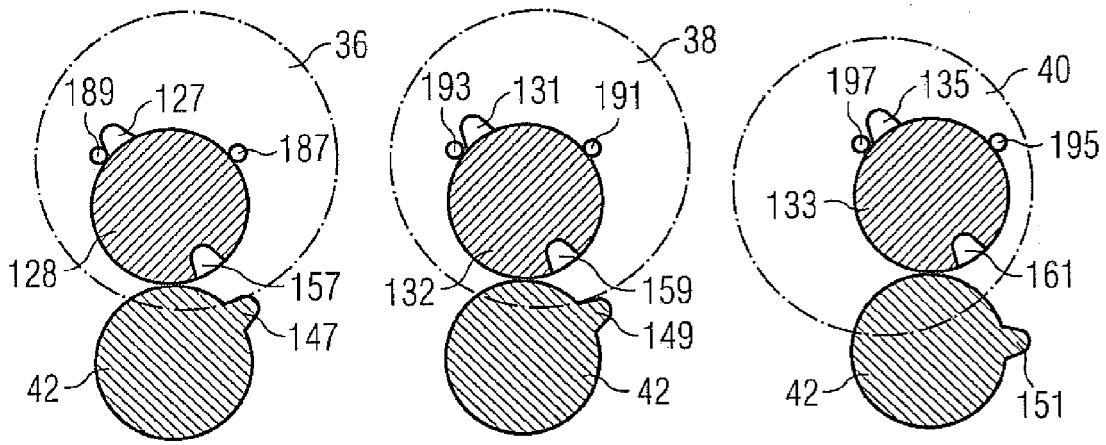


FIG 6B

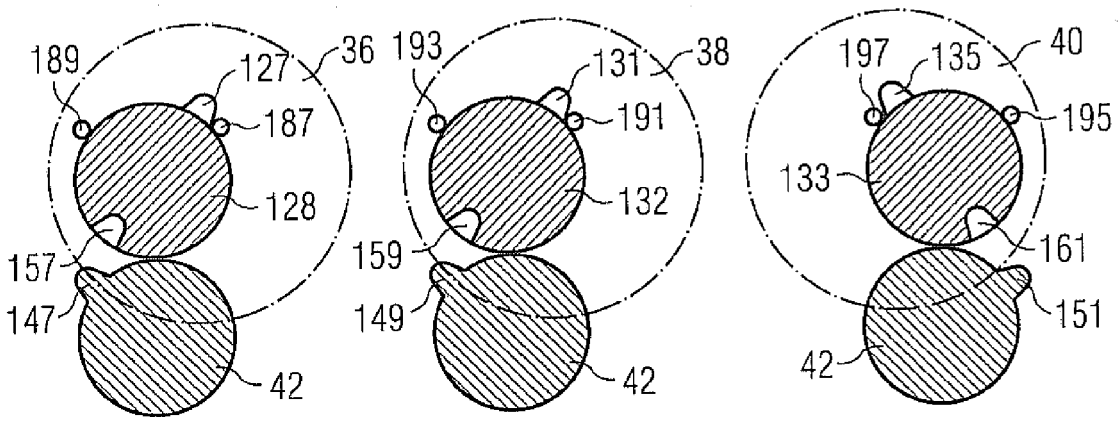


FIG 6C

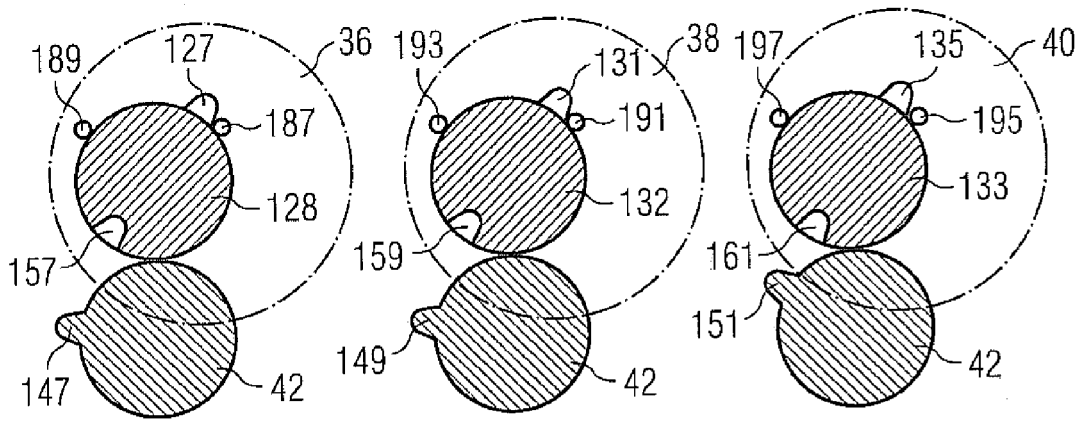


FIG 7A

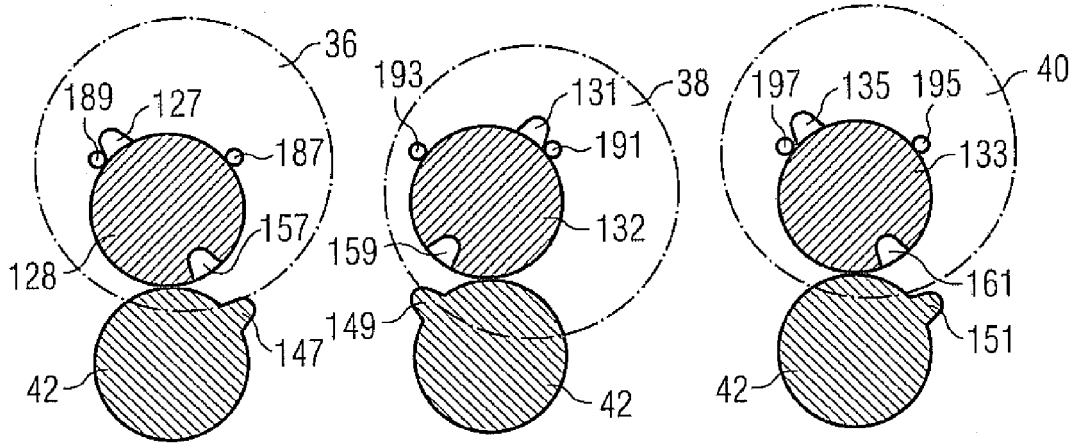


FIG 7B

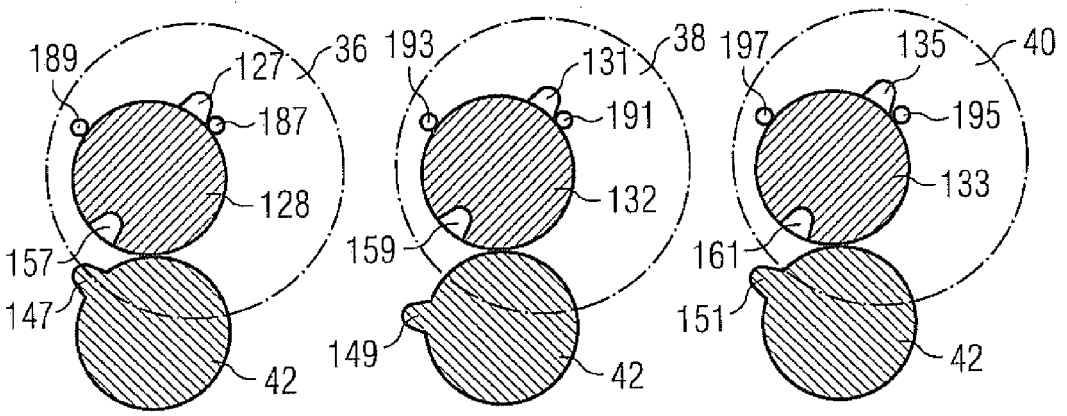
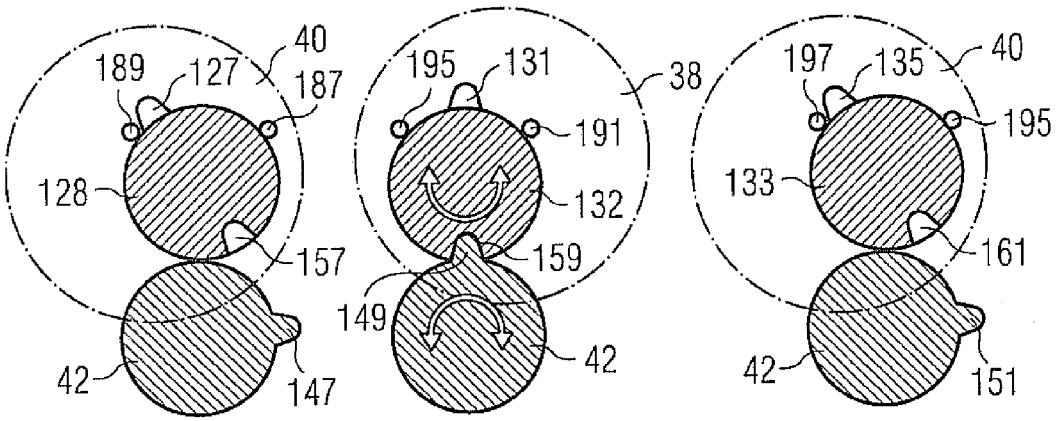


FIG 7C



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EUROPEAN SEARCH REPORT

Application Number
EP 13 15 0429

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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

Place of search	Date of completion of the search	Examiner
Munich	17 May 2013	Paulson, Bo

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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