



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
16.11.2011 Bulletin 2011/46

(51) Int Cl.:
F01L 1/18 (2006.01) **F01L 13/00** (2006.01)
F01L 1/26 (2006.01) **F02B 75/18** (2006.01)
F01L 13/06 (2006.01) **F01L 1/344** (2006.01)

(21) Application number: **10425154.1**

(22) Date of filing: **10.05.2010**

(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 SE SI SK SM TR
Designated Extension States:
BA ME RS

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Remarks:

Amended claims in accordance with Rule 137(2) EPC.

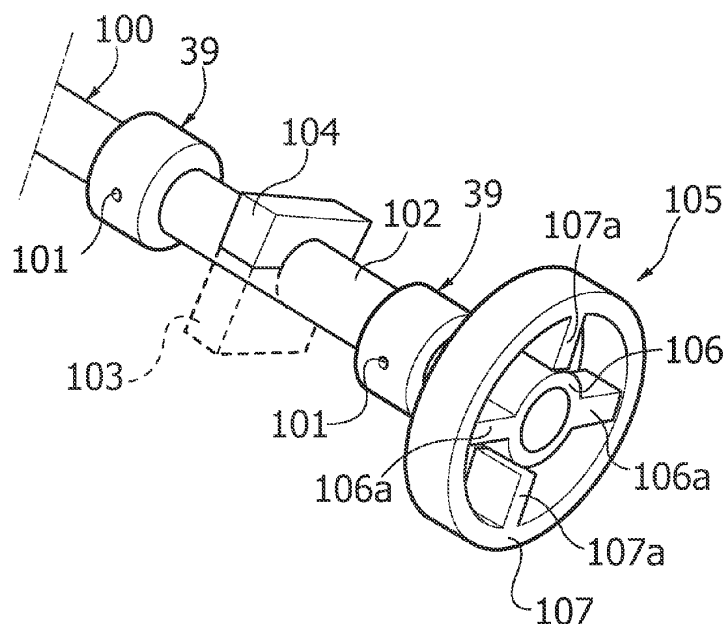
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(54) **Multi-cylinder internal combustion engine with variable actuation of the engine valves**

(57) In a multi-cylinder internal combustion engine, valves of the engine, in particular the exhaust valves (3), are actuated by rocker arms (18) each of which is rotatably mounted on the structure of the engine with the interposition of an eccentric bushing (39), whose rotation allows varying the position of the rotational axis of the respective rocker arm, so as to activate and deactivate

an extra-lift of the engine valve. The eccentric bushings (38) associated to the rocker arms (18) of the various cylinders of the engine are all connected in rotation with a common shaft (100) which is rotatably supported on the structure of the engine and which can be rotated through actuator means (105) preferably arranged outside the engine.

FIG. 2



Description

Field of the invention and prior art

[0001] The present invention refers to multi-cylinder internal combustion engines of the type indicated in the preamble of the attached claim 1. Engines of this type are illustrated in documents EP 0 543 210 B1, EP 1 927 734 A2 and EP 1 927 735 A1.

[0002] Compression braking systems for internal combustion engines, in particular for reciprocating engines such as diesel engines for heavy duty vehicles, are known. In these engines compression braking allows attaining extremely high specific braking powers, especially simultaneously with a supercharging performed by means of turbochargers with variable geometry.

[0003] It is known that such systems provide for a supplementary opening of the cylinder exhaust valve during braking, to avoid the expansion of the air in the cylinder after the compression stage, thus reducing the braking efficiency.

[0004] In order to attain such results there have been proposed various types of devices, among which in particular devices for varying the position of the rotational axis of the rocker arms which control the opening of exhaust valves.

[0005] Figure 1 of the attached drawings shows the solution known from EP 0 543 210 B1. In such figure, number 1 is used to -generally designate a multi-cylinder internal combustion engine, in particular a turbocharged diesel engine, comprising - for each cylinder - a combustion chamber (not shown in the drawing) with at least one intake conduit (also not shown in the drawing) and at least one exhaust conduit (the illustrated example shows two exhaust conduits 9 converging into an exhaust manifold 10). According to the conventional art, associated to the exhaust conduits 9 are exhaust valves 3 biased by respective springs 13 towards an upper (with reference to the drawing) closed position of the respective conduits. The engine further comprises, still according to the conventional art, at least one camshaft with cams 36 for controlling the valves, which for example can be a single camshaft intended to control both the intake valves and the exhaust valves. Each exhaust valve 3 of each engine cylinder is displaceable towards a lowered (with reference to figure 1) position for opening the respective exhaust conduit, against the action of the respective spring 13, by a rocker arm 18 rotatably mounted around a rotation axis O on the structure of the engine. The rocker arm 18 has one end freely rotatably supporting a roller 27 which cooperates with a respective cam 36 of the camshaft. The other end of the rocker arm controls the displacement of the two exhaust valves 3 associated to each cylinder, by means of a bridge-like structure (naturally a single exhaust valve for each cylinder may obviously be provided which is controlled directly by the end of the respective rocker arm).

[0006] Still according to the abovementioned prior art

solution, the cam 36 has a main lobe 58 to obtain the lifting of the exhaust valves during the exhaust stage of the operating cycle of the respective cylinder, a zero lift portion 56, which does not determine any lift of the exhaust valves, and a portion 57 slightly lifted with respect to the circular base profile for attaining a slight extra lift of the exhaust valves during the compression stage in the respective cylinder, which extra lift is actuated - simultaneously with an interruption of fuel supply to the combustion chamber - when an engine braking effect is requested.

[0007] Still according to the known solution illustrated in figure 1, the rocker arm 18 is rotatably mounted on a fixed axle onto the structure of the engine with the interposition of an eccentric bushing 39 whose angular position around the support axis may be varied. In the specific case of the illustrated example, this is done through a fluid actuator 46, also illustrated in figure 1, which operates on a lever 45 connected in rotation with the bushing 39. The variation of the angular position of the bushing 39 determines a variation of the position of the rotation axis of the rocker arm 18 with respect to the structure of the engine. When the engine-braking effect is not required, the position of the rotation axis of the rocker arm is selected in such a manner that the arm 18 is unaffected, due to the existing clearance, by the portion 57 of the profile of the cam 36, thus the extra-lift of the exhaust valves is not activated during the cylinder compression stage. On the contrary, when one wants to obtain the engine braking effect, the supply of fuel to the cylinders is cut off and the eccentric bushings 39 of the various rocker members are rotated in such a manner that the latter "feel" the profile 57 and cause the abovementioned extra-lift. In such manner, the braking effect caused by the engine during the compression stage of each cylinder is not jeopardised by an elastic re-expansion of the air in the cylinder during the subsequent stroke of the piston towards the Bottom Dead Centre, in that at least part of the air has been evacuated from the cylinder in the meanwhile.

Drawbacks of the prior art

[0008] Though guaranteeing the advantages indicated above, the aforescribed prior art device is not entirely satisfactory in terms of simplicity and cost of manufacture. Further devices of this type have been proposed in EP 1 927 734 A2 and EP 1 927 735 A1 in the attempt to simplify and reduce the number of required components but they are yet to attain an actually satisfactory result.

Object of the invention

[0009] The object of the present invention is that of proposing a device of the aforescribed type capable of allowing a dramatic simplification of the device itself with respect to those proposed previously and an ensuing dramatic reduction of the production costs.

Summary of the invention

[0010] The main characteristic of the invention is indicated in the characterizing part of the attached claim 1.

[0011] As visible, the invention provides for, equivalently to the prior art solution described above, that the rocker arms associated to the valves (in particular to the exhaust valves) of the various cylinders of the engine be rotatably supported by interposing eccentric bushings, which may be rotated to vary the position of the rotational axis of the rocker arms.

[0012] However, the eccentric bushings are not rotatably mounted each on a respective fixed axle, but rather they are connected in rotation on a common shaft which is rotatably supported by the structure of the engine.

[0013] Due to this kind of solution, the adjustment of the angular position of all the eccentric bushings associated to the various cylinders of the engine may be obtained simultaneously, through actuator means of any type suitable to rotate the abovementioned common shaft to which the eccentric bushings are connected in rotation.

[0014] For example, among various types of actuator means, a hydraulically controlled actuator device may be provided of a type similar to conventional devices used for adjusting the camshaft phase, comprising a rotor connected in rotation with the shaft supporting the eccentric bushings, and a stator fixed onto the structure of the engine and surrounding the rotor, with hydraulic means for the variation of the angular position of the rotor with respect to the stator. In any case, it is surely possible to use actuators of any other type, such as hydraulic, electric or pneumatic actuators, or also a transmission between the actuator means and the driven shaft, to increase the transmitted torque, for example a crank connected to the shaft supporting the eccentric bushings and actuated by a fluid linear actuator, or a gear transmission.

Brief description of the drawings

[0015] Further characteristics and advantages of the invention will become apparent from the description that follows with reference to the attached drawings, provided strictly for exemplifying and non-limiting purposes, wherein:

figure 1 illustrates the device for controlling the exhaust valves of a cylinder of an internal combustion engine according to the art known from EP 0 543 210 B1,

figure 2 is a schematic perspective view illustrating the base principle of the present invention,

figure 3 is a further schematic perspective view of the device according to the invention, and

figure 4 is a diagram of a possible example of an actuator used in the device according to the invention.

Description of a preferred embodiment

[0016] The prior art solution illustrated in figure 1 has already been described above. The main difference of the present invention with respect to such known solution is immediately evincible from figure 2 of the attached drawings. Such difference essentially lies in the fact that the eccentric bushings 39 associated to the rocker arms 18 for the actuation of the exhaust valves of the various cylinders of the engine are connected in rotation to a common shaft 100, instead of being freely rotatably mounted on respective axles. In the case of the embodiment illustrated in figure 2, the bushings 39 are connected in rotation on the shaft 100 by means of transverse pins 101 engaging diametric holes formed through the shaft 100 and corresponding holes diametrically opposite with respect to each other formed on each bushing 39. It is however clear that any other type of connection may be used.

[0017] Likewise, the embodiment visible in the drawings shows that the shaft 100 is rotatably supported by the structure of the engine within respective seats 102 which are defined partly by supports 103 forming part of the structure of the cylinder head of the engine and partly by caps 104 (only one of which is visible in the drawings) fixed by means of screws 104a (figure 3) to the supports 103. Preferably low friction support bearings are provided in the seats in which the shaft 100 is mounted.

[0018] Due to the abovementioned characteristic, the device according to the invention enables simultaneous adjustment of the angular position of all the eccentric bushings 39, in order to obtain the activation and deactivation of the extra-lift of the exhaust valves which has been discussed above with reference to figure 1, by simply controlling a rotation of the common shaft 100 to which the eccentric bushings 39 are fixed.

[0019] As previously indicated, the actuator means used for controlling the rotation of the shaft 100 may be of any type. In the case of the example illustrated in the attached drawings, a hydraulically controlled actuator is provided of a type similar to that used conventionally used for adjusting the camshaft phase. According to this art, known per se, the actuator, generally designated by reference number 105, comprises a rotor 106 with blades 106a which is connected in rotation with the shaft 100 and rotates within a circular stator 107 with internal blades 107a. As better visible in figure 4, defined between the rotor 106 and stator 107 are hydraulic chambers which are selectively connected to a supply pump 108 and a reservoir 109 through a control valve 110, in such a manner to control the adjustment of the angular position of the shaft 100 and hence of the eccentric bushings 39.

[0020] As clearly apparent from the foregoing description, the device according to the invention allows using one actuator for simultaneously controlling the adjusting of the position of the rocker members 18 controlling the exhaust valves of the engine cylinders. Not only is the device extremely simple and inexpensive to manufacture

but it also allows a considerable reduction of the number of components with respect to the solutions proposed previously. The device according to the invention also allows easily positioning the actuator device even outside the engine, with the ensuing advantages even in terms of reducing the temperature and vibrations to which the actuator is subjected and thus also avoiding any restrictions regarding the dimensions of the actuator and/or the type of actuator one intends to use.

[0021] As indicated severally, the means for actuating the rotation of the shaft 100 for supporting the eccentric bushings 39 may be of any type, and in particular they may be of pneumatic type, hydraulic type or electric type.

[0022] Furthermore, the device according to the invention would be identically applicable even to distribution systems using a different kinematic chain for controlling the valves, with levers of a different type with respect to the rocker arms indicated herein. Therefore, in the claims that follow, the term "rocker arm" shall be considered to include the case of any lever having a rotational movement around one axis.

[0023] Additionally, as previously indicated, a further preferred example of actuator means could be made up of a linear hydraulic actuator connected to a crank lever connected to the shaft 100. A mechanical transmission (for example a linkage or a gearing) may be generally interposed to increase the torque transmitted to the shaft 100.

[0024] It should also be observed that the eccentric bushings 39 may be each formed in a single piece or also in several pieces connected to each other. Furthermore, should the rocker arms that control the intake valves be mounted on the same rotational axis of the rocker arms which control the exhaust valves, the intake rocker arms may be freely rotatably mounted on the abovementioned common support shaft 100, in such a manner to be unaffected by the rotations of the latter.

[0025] Furthermore, the invention is obviously also theoretically applicable to devices for actuating the intake valves of the engine, in any desired case in which, for any reason, it is required to activate or de-activate an extra-lift of the intake valves through simple and inexpensive means. Lastly, the device is also applicable in any other case in which one desires to obtain an extra-lift of the exhaust valves, to obtain effects different from that of compression braking.

[0026] Naturally, without prejudice to the principle of the invention, the details and embodiments may vary, even significantly, with respect to what has been described and illustrated strictly for exemplification purposes, without departing from the scope of the present invention.

Claims

1. Multi-cylinder internal combustion engine, comprising, for each cylinder, a combustion chamber with at

least one intake conduit and at least one exhaust conduit (9), intake valves and exhaust valves (3) associated to said conduits (9) and biased by spring means (13) towards a closed condition of the respective conduit, at least one camshaft for controlling the abovementioned valves (3), each valve (3) being movable towards an opened condition of the respective conduit, against the action of the respective spring means (13), by a cam (36) of the abovementioned camshaft by means of a mechanical transmission including a rocker arm (18) rotatably mounted on the structure of the engine, wherein each of the rocker arms (18) associated to the exhaust or intake valves of the engine is rotatably mounted on the structure of the engine with the interposition of an eccentric bushing, and wherein actuator means are provided for rotating the abovementioned eccentric bushings (39) associated to the rocker arms (18) controlling the valves of the various cylinders, to vary the position of the rotation axis of the rocker arms (18),

characterised in that the abovementioned eccentric bushings (39) associated to the rocker arms (18) of the various cylinders of the engine are all connected in rotation with a common support shaft (100) which is rotatably supported on the structure of the engine, and

in that said actuator means are arranged to control a rotation of the abovementioned common support shaft (100).

2. Engine according to claim 1, **characterised in that** said actuator means (105) are positioned outside the structure of the engine.
3. Engine according to claim 1, **characterised in that** said actuator means are chosen among actuator means of the pneumatic type, actuator means of the electric type and actuator means of the hydraulic type.
4. Engine according to claim 1, **characterised in that** interposed between the actuator means (105) and the abovementioned common support shaft (100) is a mechanical transmission, such as a linkage or a gearing.
5. Engine according to claim 1, **characterised in that** the abovementioned common support shaft (100) is rotatably supported within seats (102) partly defined by supports (103) forming part of the cylinder head of the engine and partly by caps (104) fixed onto said supports (103).
6. Engine according to claim 1, **characterised in that** said actuator means are hydraulically controlled actuator means, including a rotor (106) connected in rotation with said common support shaft (100) and

rotatable within a stator (107) fixed onto the structure of the engine, said stator and rotor (106, 107) defining hydraulic chambers therebetween which can be selectively connected by means of a control valve (110) to a hydraulic supply and a reservoir.

7. Vehicle, in particular an industrial vehicle, **characterised in that** it has an engine according to any one of the preceding claims.

Amended claims in accordance with Rule 137(2) EPC.

1. Multi-cylinder internal combustion engine, comprising, for each cylinder, a combustion chamber with at least one intake conduit and at least one exhaust conduit (9), intake valves and exhaust valves (3) associated to said conduits (9) and biased by spring means (13) towards a closed condition of the respective conduit, at least one camshaft for controlling the abovementioned valves (3), each valve (3) being movable towards an opened condition of the respective conduit, against the action of the respective spring means (13), by a cam (36) of the abovementioned camshaft by means of a mechanical transmission including a rocker arm (18) rotatably mounted on the structure of the engine,

wherein each of the rocker arms (18) associated to the exhaust or intake valves of the engine is rotatably mounted on the structure of the engine with the interposition of an eccentric bushing, and

wherein actuator means are provided for rotating the abovementioned eccentric bushings (39) associated to the rocker arms (18) controlling the valves of the various cylinders, to vary the position of the rotation axis of the rocker arms (18),

wherein the abovementioned eccentric bushings (39) associated to the rocker arms (18) of the various cylinders of the engine are all connected in rotation with a common support shaft (100) which is rotatably supported on the structure of the engine, and wherein said actuator means are arranged to control a rotation of the abovementioned common support shaft (100),

characterised in that all the above mentioned eccentric bushings (39) are connected in rotation on said common shaft (100) by means of transverse pins (101) engaging diametric holes formed through the common shaft (100) and corresponding holes diametrically opposite with respect to each other formed on each bushing (39).

2. Engine according to claim 1, **characterised in that** said actuator means (105) are positioned outside the structure of the engine.

3. Engine according to claim 1, **characterised in**

that said actuator means are chosen among actuator means of the pneumatic type, actuator means of the electric type and actuator means of the hydraulic type.

4. Engine according to claim 1, **characterised in that** interposed between the actuator means (105) and the abovementioned common support shaft (100) is a mechanical transmission, such as a linkage or a gearing.

5. Engine according to claim 1, **characterised in that** the abovementioned common support shaft (100) is rotatably supported within seats (102) partly defined by supports (103) forming part of the cylinder head of the engine and partly by caps (104) fixed onto said supports (103).

6. Engine according to claim 1, **characterised in that** said actuator means are hydraulically controlled actuator means, including a rotor (106) connected in rotation with said common support shaft (100) and rotatable within a stator (107) fixed onto the structure of the engine, said stator and rotor (106, 107) defining hydraulic chambers therebetween which can be selectively connected by means of a control valve (110) to a hydraulic supply and a reservoir.

7. Vehicle, in particular an industrial vehicle, **characterised in that** it has an engine according to any one of the preceding claims.

FIG. 1

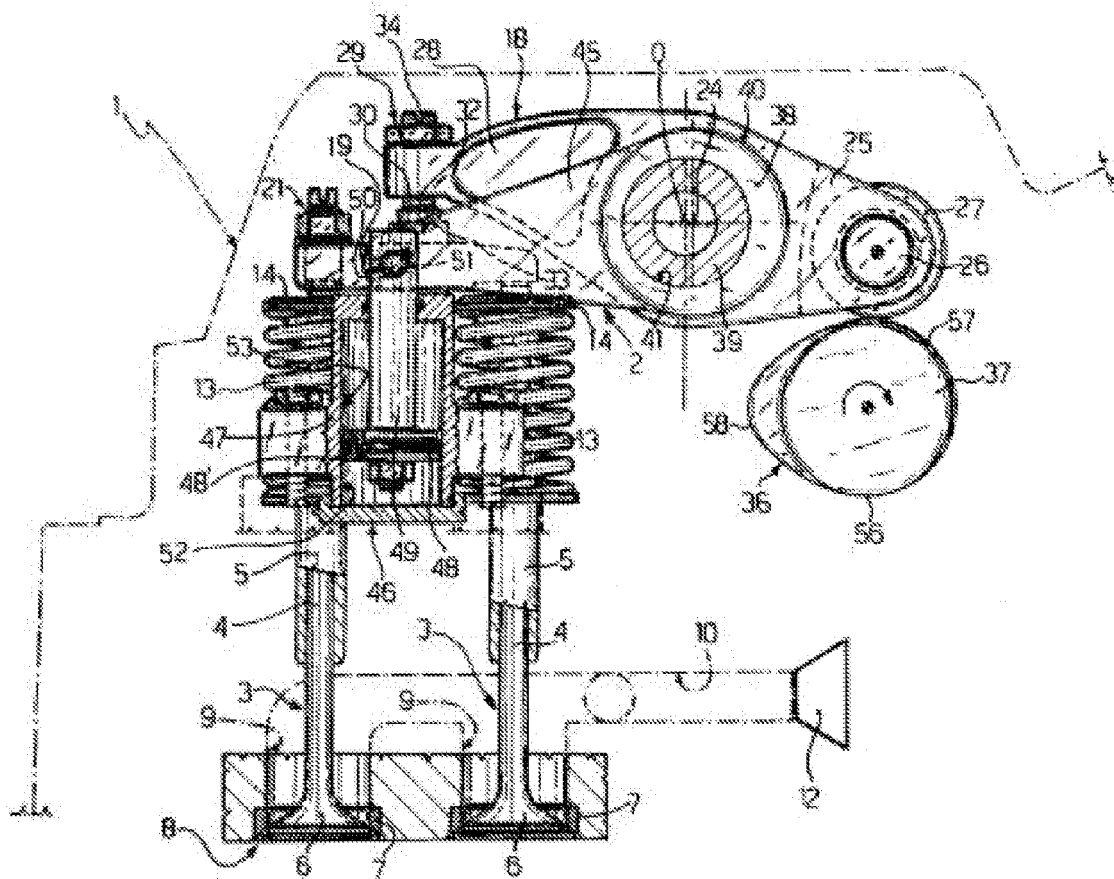


FIG. 2

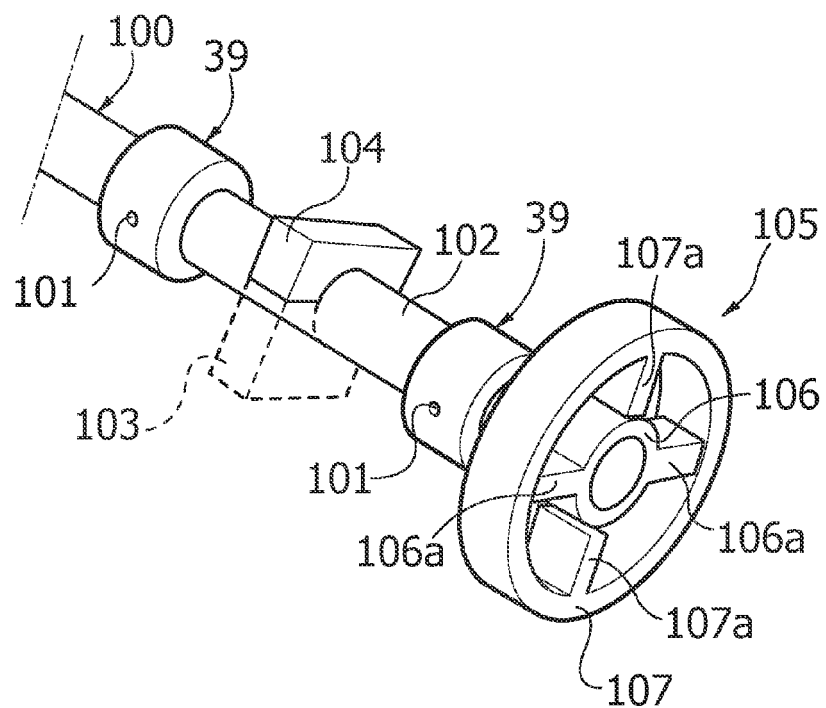


FIG. 3

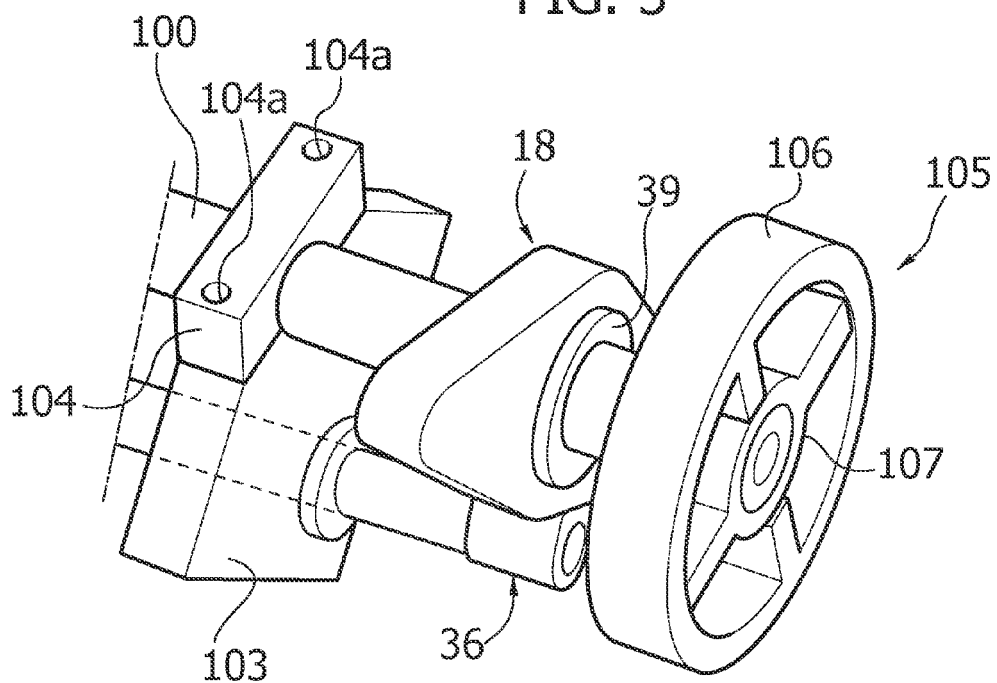
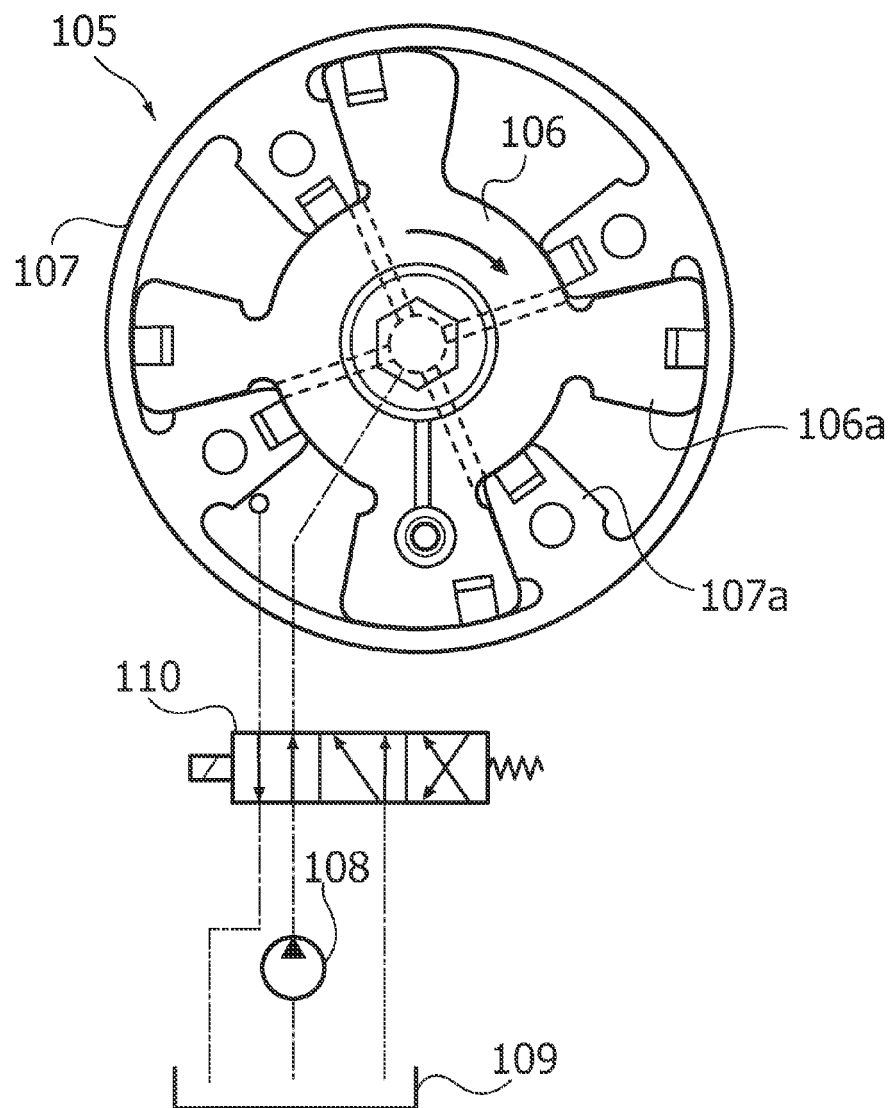


FIG. 4





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Application Number
EP 10 42 5154

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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