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European Patent Office
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(11) **EP 2 157 292 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
24.02.2010 Bulletin 2010/08

(51) Int Cl.:
F01L 13/00 *(2006.01)*

(21) Application number: **08162684.8**

(22) Date of filing: **20.08.2008**

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

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(54) **Valve gear assembly for an internal combustion engine**

(57) A Valve gear assembly for an internal combustion engine comprises a transfer device (36) interposed between the cam (18) and the valve (16) for allowing varying the valve stroke. The transfer device (36) comprises: an intermediate lever (38) having a roller assembly (40) acted upon by the cam (18) and configured to transmit an actuating force thereto; an adjustable crank element (50) comprising a guide path (52) along which the roller assembly (40) is guided; an actuator (54) for adjusting the position of the crank element (50) relative to said intermediate lever (38) so as to modify the portion of guide path (52) along which said roller assembly (40) of said actuating lever is guided. The intermediate lever (38) is fixed by a pivot (44) that is itself slideably mounted.

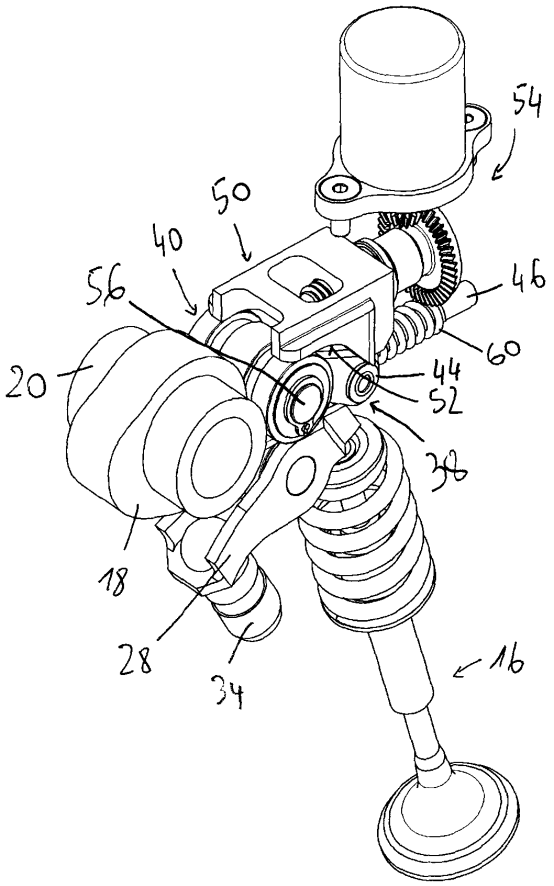

FIG.1

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Description

Technical field

[0001] The present invention generally relates to the field of internal combustion engines, and more specifically to a valve gear assembly for such engine with variable valve actuation capability.

Background Art

[0002] Valve gear systems with variable valve actuation (VVA) have been developed by automotive manufacturers to deliver refined engines that offer strong performances while also balancing fuel economy considerations.

[0003] Especially the ability of controlling and varying the valve stroke (i.e. amplitude of valve lift) permits to improve engine performances under certain operating conditions. Another appreciable feature of VVA is the possibility of deactivating certain cylinders of the engine by deactivating the respective valve(s). Cylinder deactivation can be used to increase fuel economy by deactivating certain cylinders of an engine in case of a low power demand that does not require firing of all cylinders..

[0004] The well-known BMW "Valvetronic" system for instance uses a camshaft driven VVA that comprises a pivotable intermediate lever comprising a roller acted upon by a cam. The lever comprises a shoe with a profiled surface that acts on a roller of the rocker finger follower (RFF). The valve stroke depends on the portion of the guide surface of the intermediate lever on which the RFF roller is forced to roll under the action of the cam lobe. This can be adjusted by moving the angular position of the pivoting lever, which is carried out by means of an eccentric shaft, common to all cylinders and controlled by a gear mechanism with electric motor.

[0005] US 5,373,818 describes another valve gear assembly by BMW with valves having a variable stroke. The adjustment of the stroke of these valves is also made via an eccentric shaft, which displaces the supporting point of a transfer element disposed between each cam and each stroke valve, the two eccentrics assigned to one cylinder being however of different geometry. The transfer element is formed by a valve lever, which is supported on the eccentric and is actuated by the cam, and in turn acts upon the valve stem or rocker lever, the respective contact surfaces being formed by rollers.

[0006] US 2003/0037739 relates to a further valve gear assembly with camshaft driven VVA, wherein the valves can be individually deactivated. A given cam of the camshaft actuates its associated valve using a pulley assembly, which can be displaceably guided in a sliding block part along an adjusting inclined plane, together with a valve actuating element connected in series.

[0007] The above BMW designs of valve gear assembly do not permit individual and independent valve stroke adjustment (especially deactivation). Moreover, the above designs appear to be quite complex, using many parts.

Object of the Invention

[0008] The object of the present invention is to provide an alternative valve gear assembly with individual variable valve stroke adjustment. This is achieved by a valve gear assembly according to claim 1.

General Description of the Invention

[0009] A valve gear assembly for an internal combustion engine in accordance with the present invention comprises at least one valve per engine cylinder and a camshaft with a cam for actuating a valve. A transfer device is interposed between the cam and the corresponding valve for allowing varying the stroke of the valve. According to the present invention, the transfer device comprises:

- an intermediate lever having a roller assembly acted upon by the cam and configured to be able to transmit an actuating force to the corresponding valve, the lever being pivotally mounted by a pivot that is itself slideably mounted;
- an adjustable crank element comprising a guide path along which the roller assembly is guided;
- an actuator for adjusting the position of the crank element relative to the intermediate lever so as to modify the portion of guide path along which the roller assembly of the actuating lever is guided and thereby vary the maximum valve stroke.

[0010] The present transfer device makes it possible to individually and independently control the stroke (amplitude of valve lift) of a valve. The particular design of the intermediate lever that has a sliding pivot (i.e. the lever is hinged about a pivot, which is itself slideable) results into a simple and compact valve gear system, which is especially less complex and more compact than the valve gears of US 2003/0037739 or US 5,373,818. While various constructions may be employed for the sliding pivot of the intermediate lever, in one simple embodiment the pivot has a through bore therein by which it is slidingly mounted on a shaft.

[0011] As it will be understood by those skilled in the art, the present valve gear assembly may comprise one or more inlet valves and one or more outlet valves. The respective valve lifts may be actuated by one or more camshafts and a transfer device may be provided for each valve for which a variable lift capability is desired. Typically, in today's multi-cylinders engines, two inlet valves are provided per cylinder and for improved combustion control a transfer device may be associated with each inlet valve. For a simplified assembly, a cradle el-

ement extending parallel to the camshaft may be used, on which each of the transfer devices associated with the valves actuated by the camshaft are pre-assembled.

[0012] The intermediate lever's roller assembly may comprise three rollers that are aligned on a common shaft, the central roller being in contact with the cam and the outer rollers rolling on a respective track of the guide path defined by the crank element. The guide path preferably defines a flat, idle guide portion continuing into a sloped portion. While such a cranked guide path is preferred, various shapes of the guide path may be used that comprise a zero-lift portion and an actuating portion, provided that rolling along said actuating portion will cause the intermediate lever to push the valve in actuating direction. To provide contact with both tracks of the guide path, the pivot's pivoting axis is preferably parallel to the axis of the roller assembly.

[0013] In one embodiment, the intermediate lever has a foot for transmitting the actuating force to the corresponding valve. Preferably the foot has a flat actuating surface and the transfer device is configured so that the foot's actuating surface remains parallel to the idle guide portion when the roller assembly rolls thereon due to cam actuation. In a preferred configuration, the idle guide portion of the crank element, the adjustment direction of the crank element and the axis of the pivot's sliding shaft are parallel.

[0014] Preferably, the intermediate lever is elastically biased against its respective cam to ensure a force contact with the roller assembly. This may be advantageously achieved by a compression spring fitted around the pivot's sliding shaft, resulting again in a simple and compact structure.

[0015] The actuator is advantageously provided to operate a reciprocating movement, preferably linear, of the crank element so as to adjust its position relative to the roller assembly of the intermediate lever, and thereby control the portion of guide path on which the latter runs. The technology of the actuator is not critical, but an electric motor with appropriate gearing system is preferred for ease and rapidity of operation. Preferably, for a linear reciprocating motion, the electric motor is coupled to the crank element by means of a leadscrew that is received in a threaded bore in the crank element. The leadscrew is advantageously of the self-locking type, to prevent repositioning of the crank element due to the force exerted by the cam on the transfer device and thereby allow actuator shut-off upon positioning.

Brief Description of the Drawings

[0016] Further details and advantages of the present invention will be apparent from the following detailed description of a not limiting embodiment with reference to the attached drawings, wherein:

Fig. 1: is a perspective view of a preferred embodiment of the present valve gear assembly at one inlet valve;

Fig. 2: is an exploded view of the valve gear assembly of Fig.1;

Fig. 3 and 4: is a sectional view of the valve gear assembly of Fig.1 as mounted in an engine, in a zero-lift position of the crank element for two different angular positions of the camshaft;

Fig. 5: is a sectional view of the valve gear assembly of Fig.1 as mounted in an engine, with the crank element in a non-zero valve lift position of the crank element; and

Fig. 6: is an exploded view of the intermediate lever.

Description of a Preferred Embodiment

[0017] A preferred embodiment of the present valve gear assembly is shown individually in Figs.1 and 2, while its mounting and operating principle in an internal combustion engine is illustrated in Figs. 3 to 5.

[0018] In Fig.3, reference sign 10 illustrates a cylinder head of an internal combustion engine. In the representation according to Fig.3, this cylinder head extends perpendicularly to the drawing plane along several cylinders. At least one inlet port 12 to a combustion chamber 14 exists per engine cylinder, one stroke valve 16 being provided per inlet port 12 in a known manner. This stroke valve 16 is actuated by a respective cam 18 of a camshaft 20 that may typically be driven by the crankshaft (not shown). In Fig.3, the valve 16 rests on a seat 23 surrounding port 12, i.e. the valve is in closed position.

[0019] The valve stem 22 is guided in an axial bore 24 in the cylinder head and the valve 16 is elastically biased in closing direction by means of a spring 26 surrounding the upper region of the valve stem 22. The present embodiment also employs a rocker finger follower 28 of conventional design having a rocker arm 30 with a central roller 32 that bears at one end on the top of the valve stem 16 and is supported at the opposite end by a hydraulic lash adjuster 34. The valve 16 can be lifted off the seat 23 by acting, from above, on the central roller 32 of the rocker arm 30.

[0020] It shall be appreciated that, in order to provide for an individual and valve independent stroke control of valve 16, a transfer device -generally indicated 36- acting as stroke modifying device is interposed between the cam 18 and the valve 16. As can be better seen from Figs. 1 and 2, the transfer device 36 comprises an intermediate lever 38 having a roller assembly 40 acted upon by the cam 18 and an actuating foot 42 for transmitting an actuating force to the valve 16. The lever 38 is hingedly mounted in the engine (cylinder head) by means of a pivot that is linearly slideable: one end of intermediate lever 38 is pivotable about a pivot element 44, itself slidable along a fixed shaft 46.

[0021] The transfer device 36 further comprises an adjustable crank element 50 defining a guide path 52 along which the roller assembly 40 is guided. An actuator, generally indicated 54, is provided for adjusting the position of the crank element 50 relative to the intermediate lever 38 (and consequently to the cam 18) so as to vary the portion of guide path 52 on which the roller 40 of the actuating lever 38 is guided and thereby control the maximum valve lift.

[0022] As can be best seen in Figs. 2, 3 and 6, the roller assembly 40 of the intermediate lever 38 here consists of two outer rollers 40_1 and a central roller 40_2 mounted on a common shaft 56 supported by the a pair of symmetric, bent frame members 58. The bent portion of each frame member 58 is provided with a hole 57 that receives the shaft 56 of the rollers 40_1 and 40_2, the central roller 40_2 being mounted in between the frame members 58. Actuating foot 42 is embodied by a flat connecting portion 49 bridging the two frame members 58, below the central roller 40_2. At the other extremity of lever 38, the two frame members 58 are connected to pivot element 44 via bushings 59, allowing the lever 38 to pivot about an axis parallel to that of the rollers 40_1 and 40_2. The central portion of pivot element 44 has a bore therein that allows linear sliding on fixed pin 46.

[0023] The camshaft 20 is arranged next to the intermediate lever 38 so that the cam 18 acts on the central roller 40_2. The outer rollers 40_1 bear against the respective crank paths 52 of the crank element 50. A spring 60 elastically biases the lever 38 in direction of the camshaft 20 so that the roller assembly 40 remains in contact with the cam 18.

[0024] The spacing between the two outer rollers 40_1 corresponds to the spacing between the pair of tracks of the guide path 52 on the crank element 50. Due to this configuration of the cam 18, intermediate lever 38 and adjustable crank element 50, the rotation of the camshaft 20 will cause the outer rollers 40_1 to roll on the crank path 52 of the crank element 50 and, depending on the followed portion of crank path 52, determine the extent of valve lift. In the present embodiment, the crank path 52 of the crank element 50 comprises a flat, idle portion 64 adjacent a sloped portion 66 (see Fig.5).

[0025] As it will be better understood herebelow, the configuration shown in Figs.3 and 4 is that of a zero lift, as can be used e.g. to perform so-called "cylinder deactivation". Therefore, the crank element 50 is positioned so that the roller assembly 40 of the intermediate lever 38 runs on the flat, idle portion 64 of its crank path 52. Indeed, when the crank element 50 is in the shown position, the roller 40 runs only along the flat idle path portion 64, whether the central roller 40_2 is acted upon by the cam base circle 18_1 (constant diameter) or by the cam lobe 18_2. Although the lever 38 is moved, the lower actuating surface 68 of the foot 42 remains parallel to the idle path portion 64 and, irrespective of the displacement of the intermediate lever 38, the rocker finger follower 28 is not pushed downward.

[0026] To be able to lift the valve 16 off its seat 23 and open the port 12, the crank element 50 must be moved to the left (with respect to drawing plane) by means of the actuator 54 so that the roller 40 is caused to roll on at least a part of the sloped portion 66 of the crank path 52 when the roller 40 is acted upon by the cam lobe 18_2. Such configuration is shown in Fig.5. As it will be clear to those skilled in the art, the maximum stroke of the valve 16 can be individually varied by adjusting the position of the crank element 50.

[0027] Referring now more precisely to actuator 54, it is preferably of the electromagnetic type designed to operate a linear, reciprocating movement of the crank element 50. Actuator 54 hence includes an electric motor 70 coupled to a leadscrew 72 received in a cooperating threaded bore 74 in the crank element 50. As can be seen in Figs. 3 to 5, in the shown embodiment the upper side of crank element 50 advantageously bears against a frame member 76. This frame member 76 blocks the rotation of crank element 50 about itself, so that rotation of the leadscrew 72 results in a linear displacement of the crank element 50 without requiring a supplementary guide element. The use of a self locking leadscrew 72 is advantageous to prevent repositioning of the crank element 50 due to the force exerted by the cam 20 on the transfer device and thereby allows shutting-off the actuator 54 upon positioning. As it is known in the art, the self-locking property of the leadscrew 72 can be adjusted by modifying the thread 78 parameters such e.g. as pitch and tooth attack angle. The leadscrew 72 is rotationally mounted in a bearing 80 and axially locked.

[0028] The coupling between the electric motor 54 and the leadscrew 72 is achieved by a bevel gear comprising a ring gear 82 mounted on the end of the leadscrew 72 opposite the crank element 50 that meshes with a drive pinion 84 mounted on the motor's output shaft.

[0029] Preferably, frame member 76 is designed as a cradle that allows preassembly of all the parts of the transfer device 36 and extends along the cylinder head (perpendicular to the drawing plane). This makes it possible to install at once a number of transfer devices, the cradle being then simply screwed to the cylinder head.

Claims

1. Valve gear assembly for an internal combustion engine comprising:

at least one valve (16) per engine cylinder;
a camshaft (20) with a cam (18) for actuating a valve (16);
a transfer device (36) interposed between said cam (18) and said valve (16) for allowing varying the stroke of said valve, said transfer device (36) comprising:

an intermediate lever (38) having a roller

assembly (40) acted upon by said cam (18) and configured to transmit an actuating force to said valve;
an adjustable crank element (50) comprising a guide path (52) along which said roller assembly (40) is guided;
an actuator (54) for adjusting the position of said crank element (50) relative to said intermediate lever (38) so as to modify the portion of guide path (52) along which said roller assembly (40) of said actuating lever is guided;

characterized in that said intermediate lever (38) is fixed by a pivot (44) that is itself slideably mounted.

2. Valve gear assembly according to claim 1, wherein said roller assembly (40) comprises three rollers on a common shaft (56), the central roller (40_2) being in contact with said cam (18) and the outer rollers (40_1) rolling on a respective track of said guide path (52) of said crank element (50).

3. Valve gear assembly according to claim 1 or 2, wherein said guide path (52) comprises a flat, idle guide portion (64) and a sloped portion (66).

4. Valve gear assembly according to any one of the preceding claims, wherein said intermediate lever comprises a foot (42) for transmitting an actuating force to the corresponding valve (16).

5. Valve gear assembly according to the preceding claim, wherein said foot (42) has a flat actuating surface (68) that remains parallel to said idle guide portion (64) when said roller assembly (40) rolls thereon.

6. Valve gear assembly according to any one of the preceding claims, wherein said pivot (44) has its pivoting axis parallel to the axis of said roller assembly (40).

7. Valve gear assembly according to any one of the preceding claims, wherein said pivot (44) has a through bore (45) therein by which it is slidingly mounted on a shaft (46).

8. Valve gear assembly according to any one of the preceding claims, wherein said intermediate lever (38) is elastically biased against said cam (18).

9. Valve gear assembly according to claim 7, wherein a compression spring (60) is fitted around said shaft (46) and biases said intermediate lever (38) against said cam (18).

10. Valve gear assembly according to any one of the preceding claims, wherein said actuator (54) comprises an electric motor (70) mechanically coupled to said crank element (50) for reciprocately moving said crank element (50) along a linear actuating direction.

11. Valve gear assembly according to claim 10, wherein said electric motor (70) drives a self-locking leadscrew (72) that meshes with a threaded bore (74) in said crank element (50).

12. Valve gear assembly according to claims 3, 7 and 10, wherein said idle guide portion (64), said actuating direction and the axis of said sliding shaft (46) of said pivot (44) are parallel.

13. Valve gear assembly according any one of the preceding claims, comprising a roller finger follower (28) interposed between said intermediate lever (38) and said valve (16), said foot (42) of said intermediate lever being in contact with a roller (32) of said rocker finger follower.

14. Valve gear assembly according any one of the preceding claims, wherein said transfer device (36) is pre-assembled on a cradle member (76).

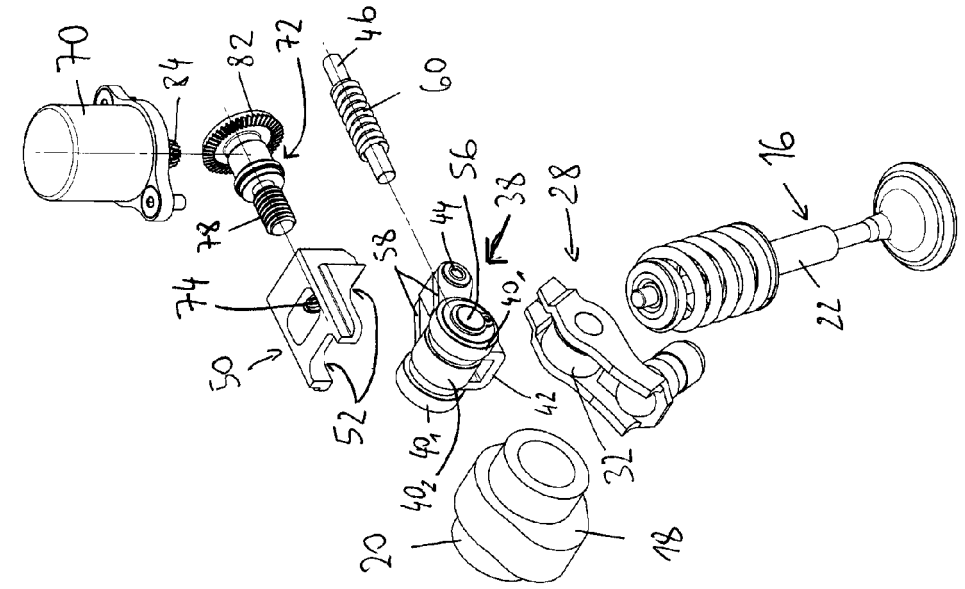
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FIG.2

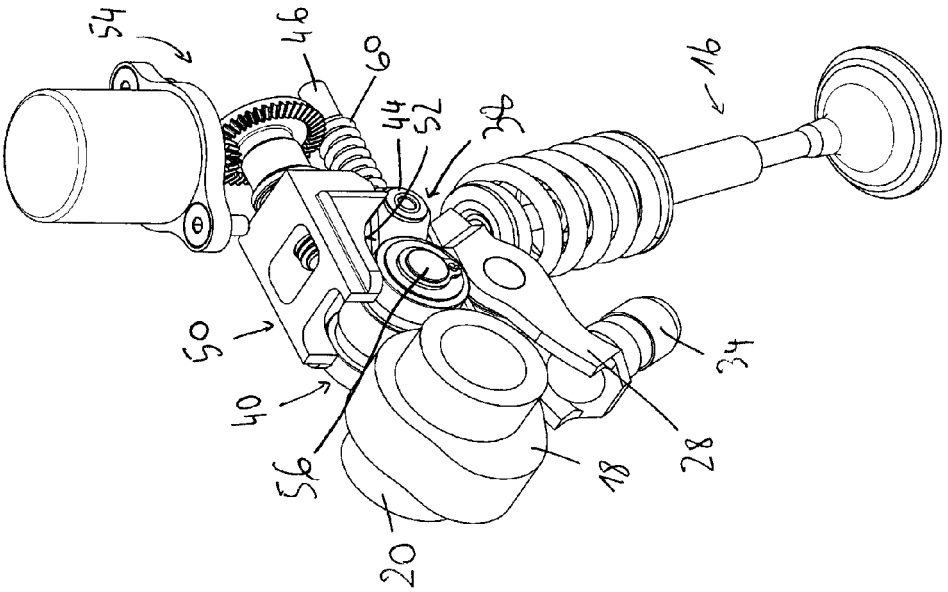
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FIG.1

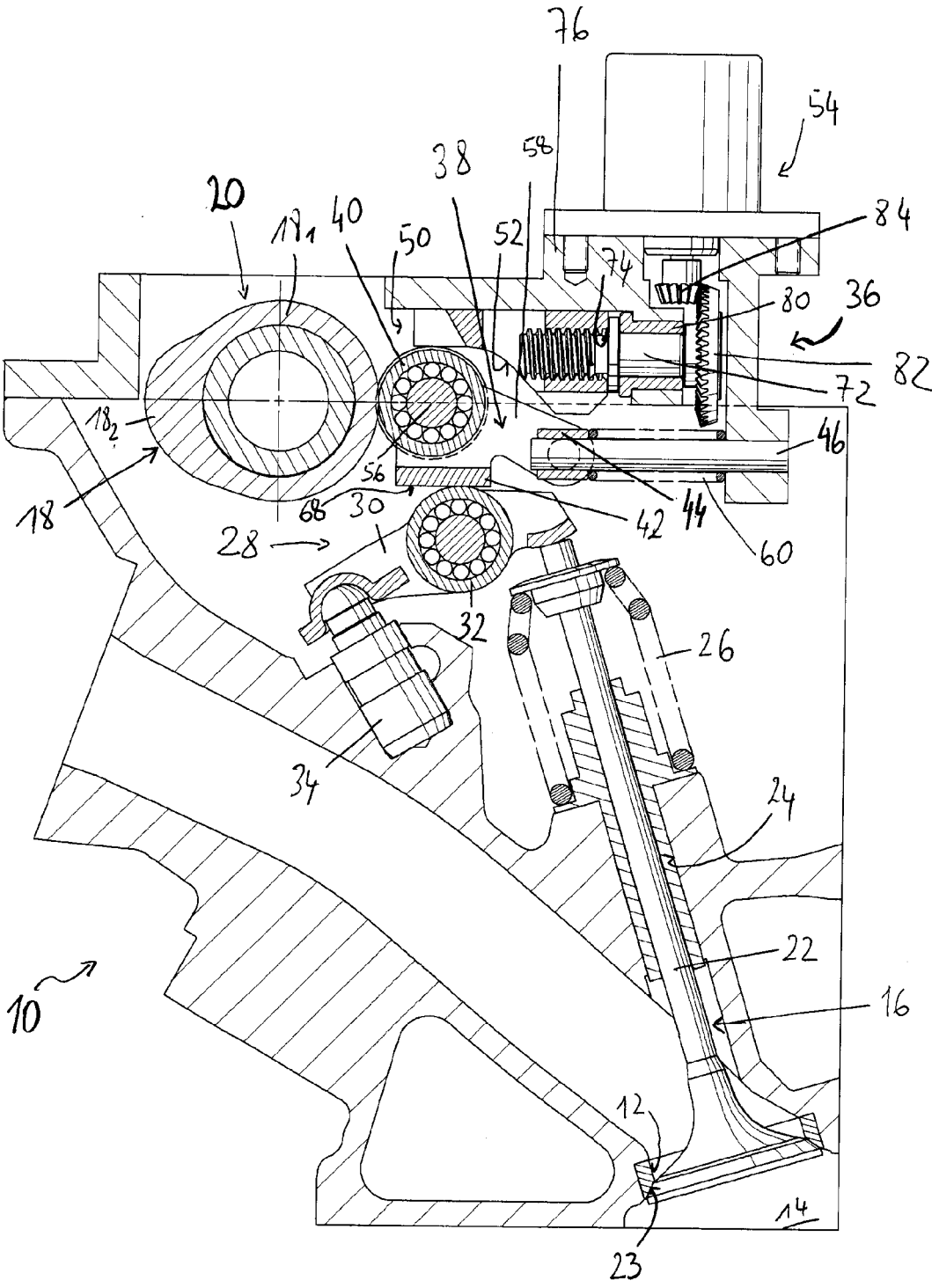
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FIG.3

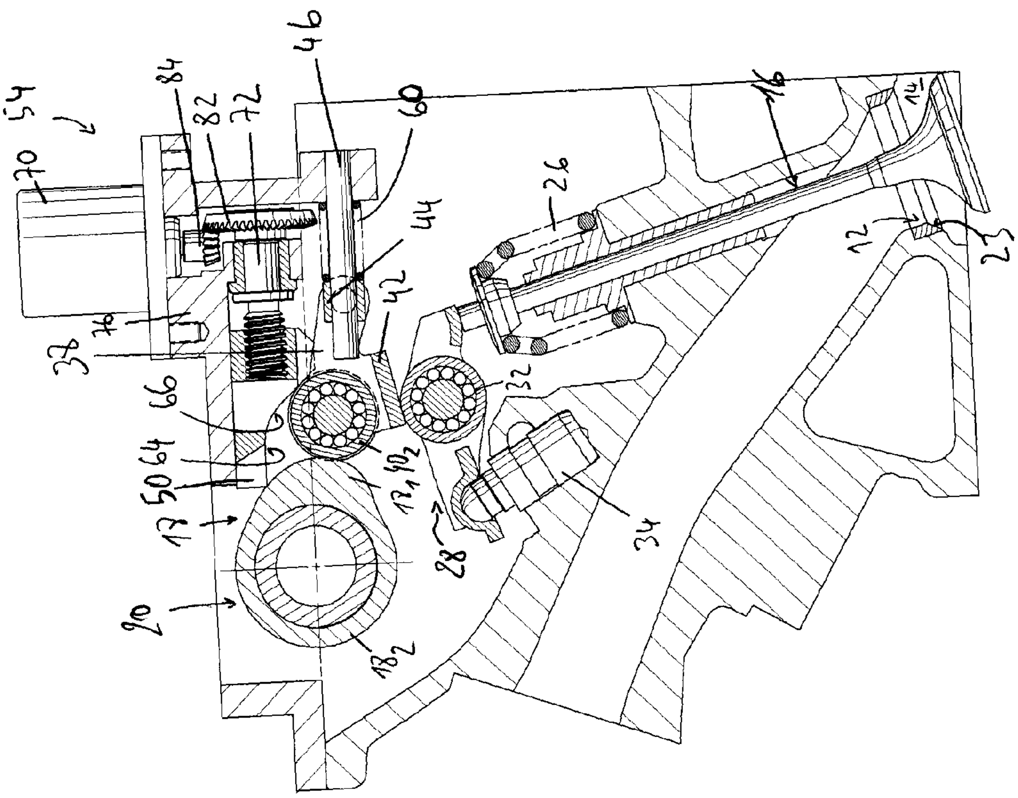

FIG.5

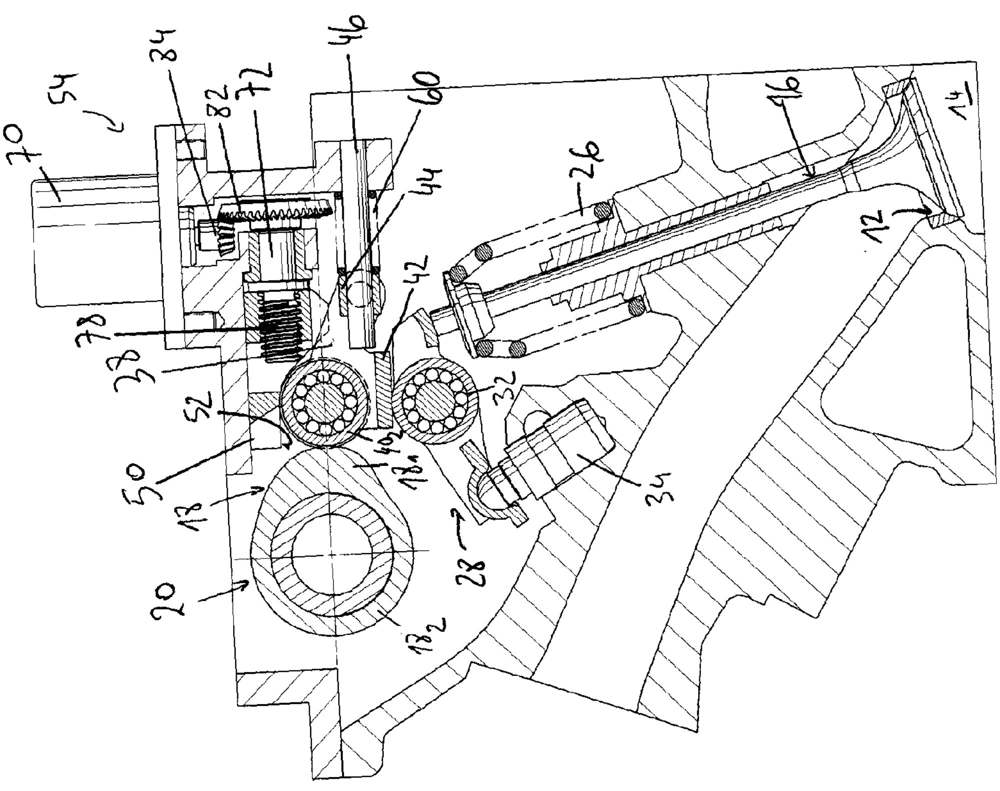

FIG.4

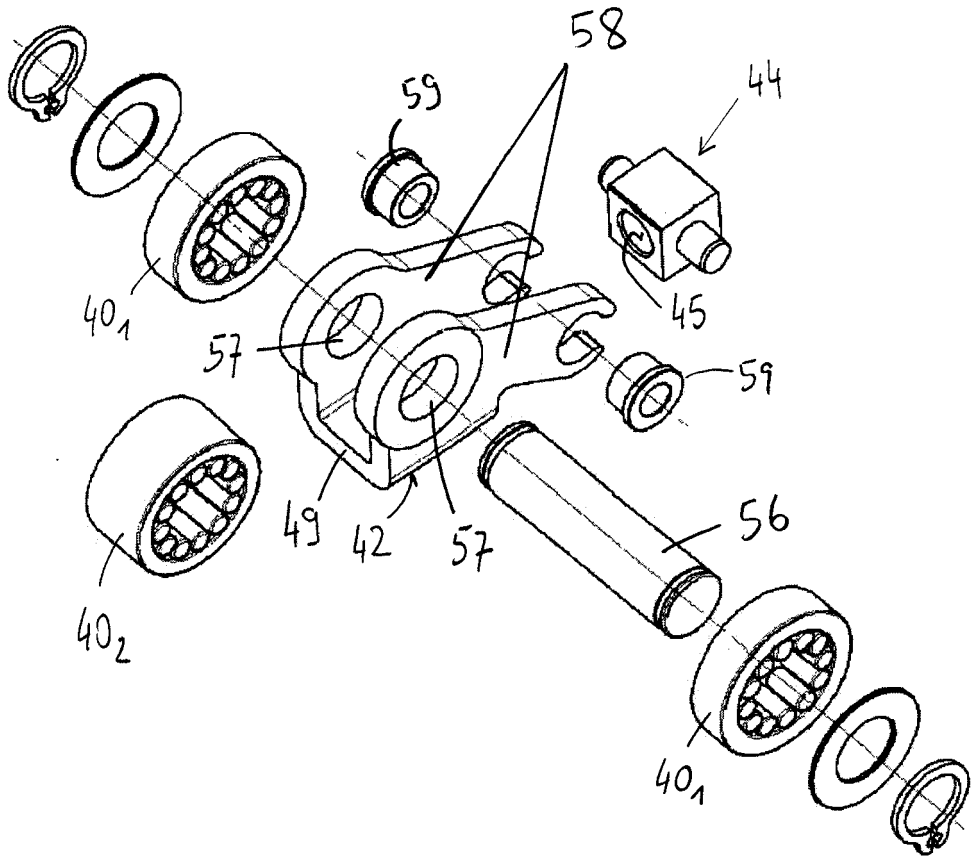

FIG. 6

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EUROPEAN SEARCH REPORT

Application Number
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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
The Hague	2 February 2009	de Mateo Garcia, I

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EUROPEAN SEARCH REPORT

Application Number
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