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

(57) A valve gear system for an internal combustion engine comprises at least one valve (12) per engine cylinder; a camshaft (11) with at least one cam (10) for actuating a respective valve (12); and a stroke modifying device (16) interposed between said cam and the associated valve. The stroke modifying device (16) comprises: an actuating element (22) slideably guided in an actuating direction (24) and adapted for transmitting an actuating force from said cam (10) to said valve (12), said actuating element (22) having a variable length in said actuating direction; and a control mechanism associated with said actuating element to adjust its length.

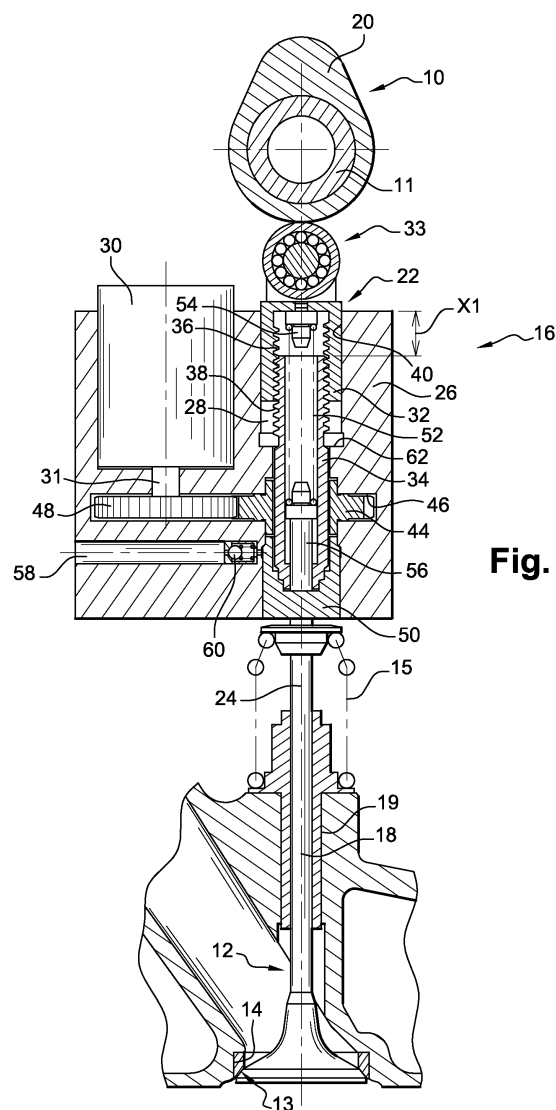


Fig. 1

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 improving 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] In more recent VVA systems an individually controllable stroke-modifying device is interposed between the cam and valve, whereby cylinder deactivation can be operated, which is not possible with the Valvetronic system. However, the design is relatively complex, as can e.g. be seen in US 2003/0037739 or EP 0 803 642.

Object of the Invention

[0006] The object of the present invention is to provide an alternative, simple valve gear assembly with individually variable valve stroke adjustment. This is achieved by a valve gear assembly according to claim 1.

General Description of the Invention

[0007] According to the present invention, a valve gear assembly includes a stroke modifying device interposed between a cam and a corresponding valve, which comprises an actuating element slideably guided in an actuating direction and adapted for transmitting an actuating

force from the cam to the valve, wherein the actuating element has a variable length in the actuating direction. A control mechanism is associated with the actuating element to adjust its length. For fast and precise adjustment of the actuating element whilst the engine is running, the control mechanism preferably includes an electric motor.

[0008] The valve stroke (amplitude of valve lift) can thus be easily adjusted by modifying the length of the sliding actuating element, a shortening or lengthening of the actuating element resulting into a corresponding modification of the valve stroke. The present invention provides a simple and efficient way of individually controlling the stroke of a valve. As it will appear to those skilled in the art, the design of the present stroke-modifying device may be considerably simpler than those using pivoting levers or hydraulic pistons.

[0009] Basically, the actuating element may comprise an input member, an output member and length adjusting means operable to bring said input and output members closer or farther in the actuating direction. Actuation of the length adjusting means is then performed via the control mechanism (e.g. comprising the electric motor coupled to the adjusting means) and permits adjusting the length of the actuating member. A simple and reliable length adjusting means may involve a bolt-and-nut joint, preferably configured as leadscrew.

[0010] In a practical embodiment, the input and output members are threadedly engaged within one another, whereby the length of the actuating element can be adjusted by directly screwing or unscrewing one of these members.

[0011] The coupling between the e-motor and actuating element is thus advantageously designed so as to allow selective rotation of one of the input and output members relative to the other member, while allowing sliding of the rotated member (and actually of the actuating member) in the actuating direction. Such coupling may comprise an externally toothed ring gear fitted over the output member and meshing with one or more gears connected with the e-motor's output shaft. The ring gear is further provided with internal splines that cooperate with external splines on the output member to provide for relative axial movement and a fixed rotational relationship.

[0012] Preferably, a pushrod is aligned with said actuating element in said actuating direction and interposed between actuating element and the valve.

[0013] The various elements of the stroke modifying system may be accommodated inside a housing, wherein the actuating element, and preferably the pushrod, are slideably received in a guide bore.

[0014] To limit shocks and noise in the valve train, the actuating element is elastically biased towards the cam. For example a compression spring may be arranged inside the actuating element, the latter being open towards the valve so that one end of the spring bears on an inner surface of the actuating element and the other on a counter-surface outside the actuating element.

[0015] For smoothness of operation, an oil feed channel advantageously opens into the guide bore where the actuating element and pushrod reciprocate. The presence of oil in the guide bore also permits to reduce shocks and noise by configuring the interface between the actuating element and the pushrod so as to provide a hydraulic brake. A further hydraulic brake may be provided at the interface between the pushrod and a locking shoulder limiting the displacement of the pushrod towards the cam.

[0016] 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 stroke modifying 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 stroke modifying device may be associated with each inlet valve. The stroke modifying device is particularly suitable for use with so-called type 1, type 2 and type 5 valvetrains, but not exclusively.

Brief Description of the Drawings

[0017] 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 section view through a preferred embodiment of the present valve gear assembly at one inlet valve, with the stroke-modifying device configured for full-lift;

Fig.2: is an exploded view of the stroke-modifying device of Fig.1;

Figs. 3-5: are section views through the stroke-modifying device respectively in lobe-engaged full-lift configuration, non-engaged zero-lift configuration and lobe-engaged zero-lift configuration;

Figs. 6 is a detail view illustrating the interface at pushrod shoulder 50 and locking shoulder 64 spaced by Z1 before abutment;

Figs. 7 is a detail view illustrating the interface at actuating element shoulder 74 and pushrod shoulder 78 spaced by Z2 before abutment.

Description of a Preferred Embodiment

[0018] A preferred embodiment of the present valve gear assembly is shown in the Figs. Reference 10 indicates a cam of a camshaft 11 associated with an inlet valve 12 for its actuation, in order to open or close an inlet port 14 to an engine cylinder. The camshaft 11 may typically be coupled to the engine crankshaft (not shown)

by means of a sprocket wheel and chain or pulley and belt (not shown), as is known in the art. In Fig.1, valve 12 rests on a seat 13 surrounding port 14, i.e. the valve is in closed position. Conventionally, the valve stem 18 is slideably guided in an axial bore 19 in the cylinder head and the valve 12 is elastically biased in closing direction by means of a spring 15 surrounding the upper region of the valve stem 18.

[0019] In order to be able to vary the opening stroke (amplitude of valve lift) of valve 12, a stroke-modifying device, generally indicated 16, is interposed between the cam 10 and corresponding valve 12. This stroke-modifying device 16 is designed to be able to transfer an actuating force to the valve stem 18 when acted upon by the lobe 20 of cam 10 and to permit selective, variable alteration of the valve stroke.

[0020] Accordingly, device 16 comprises an actuating element 22 slideably guided in an actuating direction 24, which is coaxial with the actuating direction of the valve (stem 18 axis). As can be seen in Fig.1, a housing 26 has a through bore 28 therein, in which the actuating element 22 is slideably received to allow reciprocating movement thereof in the axial actuating direction 24. The actuating element 22 has a variable length and is associated with an electric motor 30 coupled thereto so as to allow selective length adjustment.

[0021] In the present embodiment, the actuating element 22 consists of an input member 32 and an output member 34 that are threadedly engaged with one another. The input member 32 has a general pot-shape with its opening oriented towards the valve 12. Since the input member is in contact with the cam, it preferably comprises a roller bearing 33 mounted to the pot base that protrudes out of the housing 26. The tubular wall of input member 32 is provided with an inner thread 36 that is engaged by an external thread 38 on the tubular output member 34. Preferably this threaded joint is designed as leadscrew, which self-locking feature avoids any modification of the relative positions of the input and output members 32 and 34 under the force applied by the cam lobe 20.

[0022] Accordingly, since the cooperating threads 36, 38 extend in actuating direction 24, screwing or unscrewing one of the input 32 or output 34 members permits to bring the extremities of said members 32 and 34 closer or farther, and thereby reduce or increase the actuating member's 22 length.

[0023] In the present variant, the input member 32 is locked against rotation in the housing 26, e.g. by means of one or more axial splines (not shown) that interlock with corresponding axial grooves (not shown) in the input section 40 of the through bore 28. The output member 34 is coupled to the e-motor 30 so that it can be rotated relative to the input member 32 while permitting sliding in the actuating direction 24.

[0024] Therefore, the input shaft 32 is provided with external splines 42 below the treaded section 38 (closer from the valve 12) that extend in the actuating direction

24. An externally toothed ring 44 is fitted over the splined section of output member 34 and its inner periphery is provided with grooves that cooperate (interengage) with the external splines 42 on output member 34. As a result, ring 44 and output member 34 are in fixed rotational relationship but relative axial movement is possible. Ring 44 is received in an appropriately shaped recess 46 in housing 26 so that it may rotate about axis 24 but is locked axially, i.e. it cannot move in the direction of axis 24. Ring 44 is in turn coupled to the e-motor 30 via an externally toothed pinion 48 directly mounted on the e-motor's 30 output shaft 31.

[0025] Energizing the e-motor 30 causes rotation of pinion 48 and thus of ring 44 and output member 34, which is integral in rotation therewith. Since input member 32 is rotationally locked, the rotation of output member 34 causes an axial displacement of the output member's thread 38 along the threaded portion 36. Depending on the direction of rotation of e-motor 30, it either implies screwing or unscrewing of the output member 34 with respect to the input member 32, and thus shortening or lengthening of the actuating element 22.

[0026] As it can be seen in the Figs., a push rod 50 is preferably located intermediate the actuating element 22 and the valve 12. Pushrod 50 is axially slideable in guide bore 28 and dimensioned so that it may protrude there out over a part of its length for actuating the valve 12.

[0027] Further to be noted is spring 52 arranged inside the actuating element 22 so that the actuating element 22 is in permanent contact with the cam 10. Spring 52 is centrally maintained by an upper centering element 54, screwed in the input member 32, and a lower centering element 56 that is slideable through the bottom opening of output member 34 and rests against the pushrod 50.

[0028] In Figs. 1 and 3, the stroke modifying system 16 is configured to perform a maximum stroke, i.e. the stroke amplitude is not altered and is thus equivalent to the case where the cam would directly bear on the valve stem. In this configuration, the length of the actuating element 22 is such that the actuating element 22 is in contact with the cam base circle and simultaneously in contact with the pushrod 50, itself bearing on the valve stem. A downward displacement of the actuating element 22 under the action of the cam lobe 20 results in an equivalent downward displacement of the valve stem, of same amplitude. The actuating force of the cam lobe 20 is thus immediately transferred to the valve stem.

[0029] In order to reduce the valve stroke, it suffices to energize the e-motor 30 so that the output member 34 is screwed into the input member 32, which thus shortens the length of the actuating member 22. Advantageously, the present system 16 is designed so that the stroke can be adjusted from a desired maximum stroke down to a zero-stroke, where the valve is in fact not lifted off its seat 13.

[0030] The zero-lift configuration of the stroke modifying system 16 is illustrated in Figs 4 and 5. As can be seen, the output member 34 has been screwed deep

inside the input member 32, whereby there is a gap G between the bottom end of the actuating element 22 and the pushrod 50, since the actuating element 22 has been shortened as compared to Fig. 1 and is pushed upwards by spring 52. In Fig. 4, the actuating element 22 is in contact with the base circle region of cam 10; but as soon as it will be driven by the lobe portion 20 the actuating element 22 will progressively move downward and this until reaching the lobe's apex.

[0031] However, as explained, the shortening of the actuating element 22 has created the gap G between the latter and the pushrod 50. And as it will be understood, in order lift the valve 12 off its seat 13, it is necessary that the actuating element 22 actually pushes the pushrod 50 downward that in turns pushes the valve 12 downward, i.e. in the opening direction.

[0032] In the configuration of Figs. 4 and 5, the actuating element 22 has been shortened by an amount that corresponds to the distance between the lobe's apex and the base circle, indicated L in Fig. 4. Therefore, the gap G has the same axial length as this distance L so that under the action of the lobe 20, the actuating element 22 will simply move downward reducing the gap G down to zero, until it comes into contact with the pushrod 50, but without causing a downward displacement of the pushrod 50. Accordingly, no actuating force is transmitted from the camshaft to the valve stem 24 and the valve 12 remains closed. As it will be understood, this also implies that the lengths G and L equal the distance (X1-X2) by which the length of the actuating element has been reduced between Figs. 1 and 4.

[0033] While the drawings concern two extreme configurations, the present system 16 allows performing a valve lift event of any intermediate amplitude, since the threads 36 and 38 form a continuous length adjusting means for the members 32 and 34.

[0034] Reference sign 58 indicates an oil channel that opens into the lower section of bore 28 and provides for smoothness of operation, since the whole bore 28 is lubricated as well as the gearing. A check valve 60 prevents back flow into the feed channel 58.

[0035] For safety and mounting reasons, an annular shoulder 62 in bore 28 limits the downward displacement of actuating element 22 while another annular shoulder 64 blocks the upward movement of pushrod 50 (see Fig. 6). Preferably, the interface between the shoulder 64 and pushrod 50 is designed as a hydraulic brake, i.e. the impact between both is dampened by oil. This is obtained by providing an annular groove 66 just before a peripheral shoulder 68 on the pushrod 50 that will abut against shoulder 64, which delimits an annular groove 70 in bore 28 in which channel 58 opens. Accordingly, when the pushrod 50 moves upward a certain volume of oil will be trapped between these grooves and dampen the abutment between flanges 64 and 68, thereby ensuring a soft landing of the valve 12.

[0036] Another hydraulic brake is preferably provided at the interface between the actuating element 22 and

pushrod 50, thereby ensuring a soft take-off of the valve 12. Similarly, an annular groove 72 (see Fig. 7) is provided before a front shoulder 74 on the output member 34, while an annular groove 76 is provided before the corresponding shoulder 78 in the pushrod 50.

[0037] The present stroke modifying devices provides for direct mechanical actuation of the valve while benefiting from a variable and flexible actuation by way of the e-motor 30 whilst the engine is running. Preferably the length adjustment is carried out when the device is not engaged by the lobe 20 portion, i.e. when the roller 33 is in contact with the base circle, during which the load on the device is clearly lower.

[0038] The stroke modifying device may comprise control electronics driven by the Engine Control Unit or its control may be fully integrated in the latter. The power of e-motor 30 is to be adapted to the desired torque and rotating speed. If the engine speed, and thus camshaft speed is to high to reduce the actuating element's length by the desired value (e.g. from X1 to X2) over one camshaft revolution, the length reduction (or increase) can be controlled over two or more camshaft revolutions.

[0039] Sensors may advantageously be employed to monitor the actual amplitude of the valve lift. This may be done *i.a.* by means of a sensor to directly detect the valve position, by determining the actual length of the actuating element 22, or based on the number of revolutions of the electric motor. In this latter case, a brushless DC motor with hall sensors is preferred, whereby the actual valve lift amplitude is calculated from the rotation information provided by the hall sensors.

[0040] As it has been explained before, the present system can provide a valve stroke adjustment with an amplitude varying from 0 to 100% of a predetermined maximum (nominal) stroke.

[0041] As it will be understood by those skilled in the art, the present embodiment concerns a type-1 valve where the stroke modifying device 16 directly acts on the valve stem. Accordingly, there is a 1 to 1 ratio between the displacement of the actuating element 22 and that of the valve 12. While a roller 33 is used at the top of the actuating element 22 to be in contact with the cam 10, it could be replaced by a conventional tappet structure.

[0042] Besides, in the case of a type-2 valvetrain, the stroke modifying device would act upon a Rocker Finger Follower, in which case the actuating ratio would depend on the RFF configuration.

Claims

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

at least one valve (12) per engine cylinder;
a camshaft (11) with at least one cam (10) for actuating a respective valve (12);
a stroke modifying device (16) interposed be-

tween said cam and the associated valve;

characterized in that said stroke modifying device (16) comprises:

an actuating element (22) slideably guided in an actuating direction (24) and adapted for transmitting an actuating force from said cam (10) to said valve (12), said actuating element (22) having a variable length in said actuating direction; and
a control mechanism associated with said actuating element to adjust its length.

2. Valve gear system according to claim 1, wherein said actuating element (22) comprises an input member (32), an output member (34) and length adjusting means operable to bring said input and output members (32, 34) closer or farther in the actuating direction (24).

3. Valve gear system according to claim 2, wherein said length adjusting means employs a bolt-and-nut joint, preferably configured as leadscrew.

4. Valve gear system according to claim 2 or 3, wherein said input and output members are threadedly engaged with one another, the length of said actuating element (22) being adjustable by screwing or unscrewing one of said members (32, 34).

5. Valve gear system according to any one of the preceding claims, wherein said control mechanism comprises an electric motor (30) coupled to said actuating element (22).

6. Valve gear system according to claim 5, wherein said output member (34) is provided on its outer surface with splines (42) extending parallel to said actuating direction (24); and
an externally toothed ring gear (44) is fitted over said output member (34) and provided with internal splines interengaging said external splines (42) of said output member (34), said ring gear (44) being coupled to the electric motor's output shaft.

7. Valve gear system according to any one of the preceding claims, comprising an elastic member (52) biasing said actuating element (22) towards said cam (10).

8. Valve gear system according to claim 7, wherein said actuating element (22) is open towards said valve (12) and said elastic member (52) is a compression spring fitted inside said actuating element and protruding outside its open end.

9. Valve gear system according to any one of the pre-

ceding claims, comprising a housing (26) with a guide bore (28) therein in which said actuating element (22) is slideably received.

10. Valve gear system according to any one of the preceding claims, comprising a slideable pushrod (50) aligned with said actuating element (22) to actuate said valve (12). 5
11. Valve gear system according to claim any one of the preceding claims, comprising an oil feed channel (58) opening into said guide bore 280. 10
12. Valve gear system according to claims 13 and 12, wherein the interface between said actuating element (22) and said pushrod (50) is configured to provide a hydraulic brake. 15
13. Valve gear system according to claims 10 and 11, wherein said guide bore (28) comprises a locking shoulder (64) limiting the displacement of said pushrod (50) towards said cam (10), the interface between said locking shoulder and pushrod being configured to provide a hydraulic brake. 20
14. Valve gear system according to any one of the preceding claims, wherein said input member (32) comprises a roller (33) acted upon by said cam (10). 25

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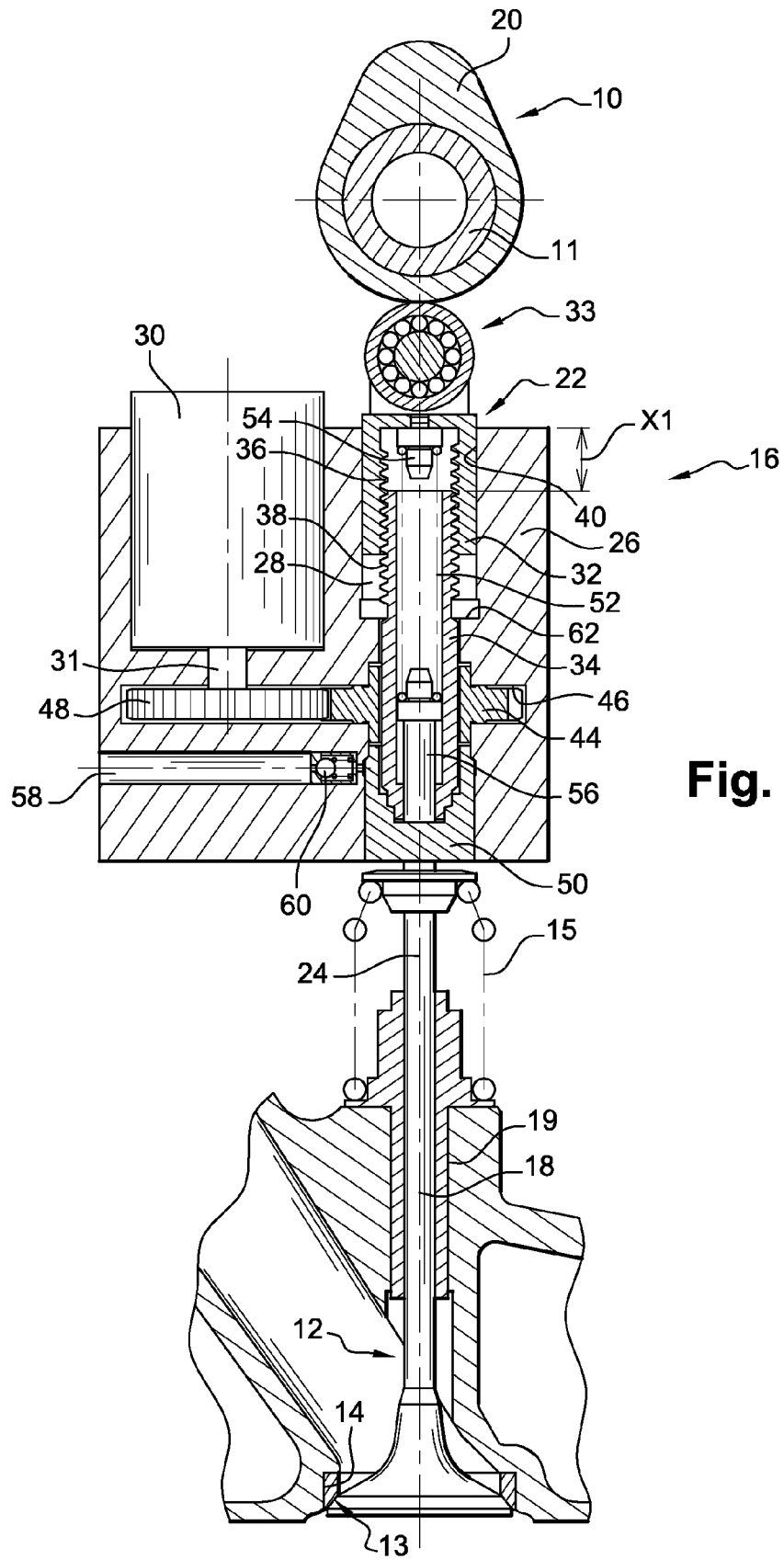
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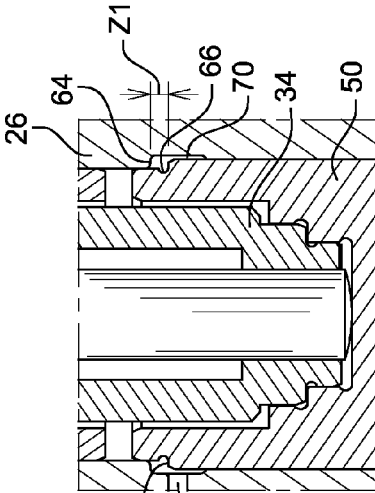


Fig. 6

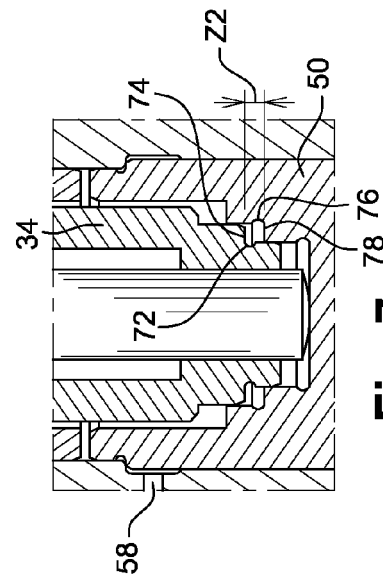


Fig. 7

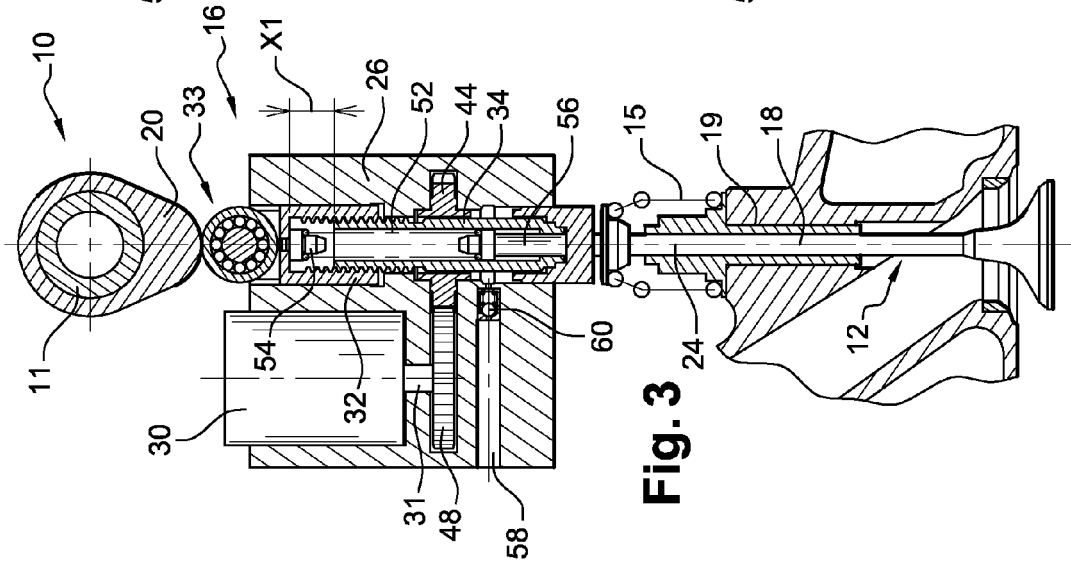


Fig. 3

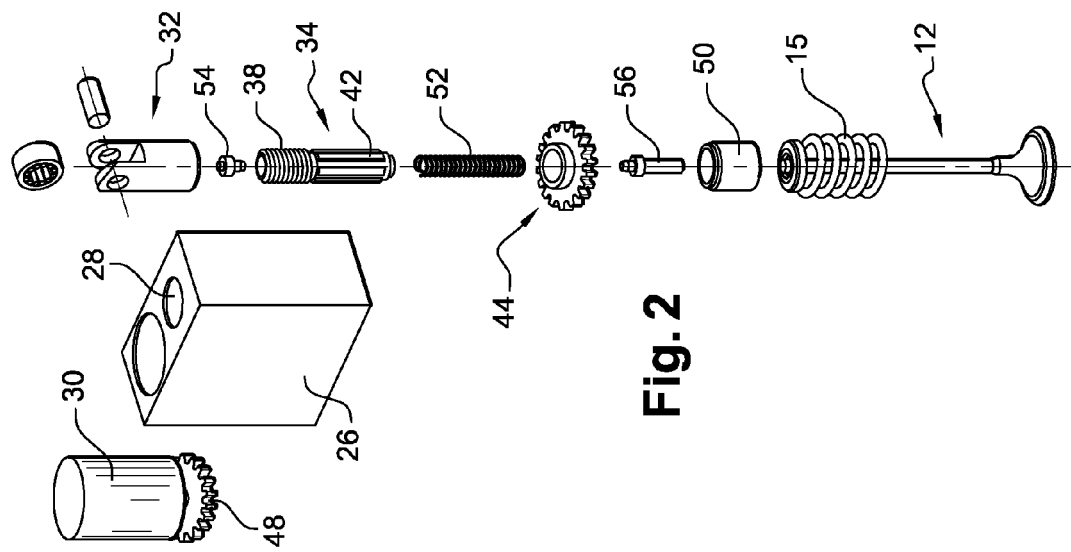


Fig. 2

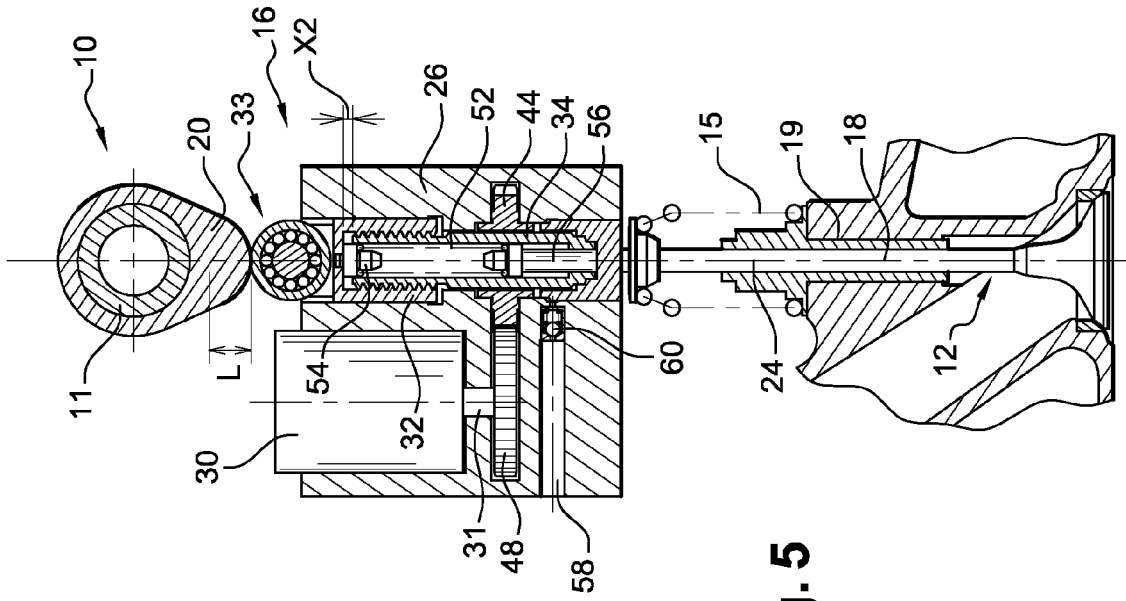


Fig. 5

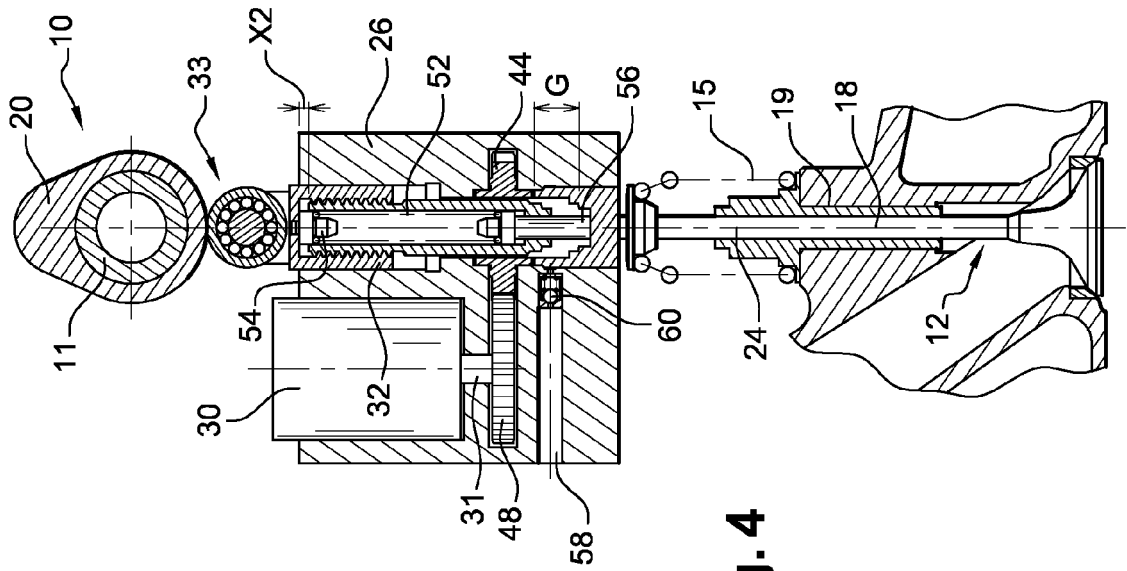


Fig. 4



EUROPEAN SEARCH REPORT

Application Number
EP 08 16 8367

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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 The Hague		Date of completion of the search 25 March 2009	Examiner Paquay, Jeannot
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EP 08 16 8367

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25-03-2009

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