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AN INTERNAL COMBUSTION ENGINE COMPRISING LOAD ADJUSTING SPRING

(57)

An internal combustion engine (1) comprises an engine block (2), a poppet valve (3) which is slidably mounted to the engine block (2), a camshaft (7) for operating the poppet valve (3) which camshaft (7) is rotatably mounted to the engine block (2), a valve spring (4) which is fixed to the poppet valve (3) and resting on a spring seat (6) of the engine block (2) and a load adjusting

spring (14) for exerting a spring force on the poppet valve (3). The load adjusting spring (14) has a first portion (13) which cooperates with an actuator (9-12) for displacing the first portion (13) with respect to the spring seat (6) and a second portion (15) located at a distance from the first portion (13), which second portion (15) cooperates with the poppet valve (3).

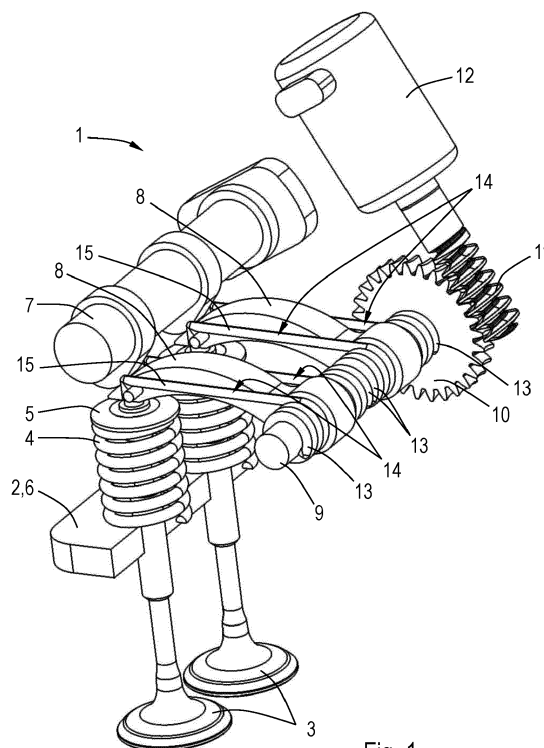


Fig. 1

Description

[0001] The present invention relates to an internal combustion engine comprising an engine block, a poppet valve which is slidably mounted to the engine block, a camshaft for operating the poppet valve which camshaft is rotatably mounted to the engine block, a valve spring which is fixed to the poppet valve and resting on a spring seat of the engine block and a load adjusting spring for exerting a spring force on the poppet valve.

[0002] In most internal combustion engines poppet valves are used to open and close the intake and exhaust ports in the cylinder head. Usually, the valve spring is compressed upon installation in an engine in order to assure the poppet valve to close the corresponding intake or exhaust port. The force required to keep the poppet valve closed at high engine speed is higher than that required at a relatively low engine speed in order to avoid a condition of valve float in which condition the poppet valve does not properly follow the closure phase of a cam lobe profile. Therefore it used to be customary to compress the valve spring upon installation in an engine, by an amount sufficient to provide the higher preload force. Later valve systems introduced a variable preload in order to reduce friction force in the valve train during low speed operation of the engine.

[0003] An internal combustion engine including a system as described above is known from DE 35 25 626. The valve closing force during high-speed operation can be increased by allowing a load adjusting spring to exert an additional force on the poppet valve.

[0004] An object of the invention is to provide an internal combustion engine in which the force on the poppet valve can be adapted gradually upon varying engine speed.

[0005] This object is accomplished with the system according to the invention, wherein the load adjusting spring has a first portion which cooperates with an actuator for displacing the first portion with respect to the spring seat and a second portion located at a distance from the first portion, which second portion cooperates with the poppet valve.

[0006] When displacing the first portion of the load adjusting spring with respect to the spring seat, the second portion will exert a different spring force onto the poppet valve. This provides the opportunity to vary the spring force on the poppet valve gradually rather than stepwise like the above-described prior art system. At relatively low engine speed the first portion of the load adjusting spring can be positioned such that a relatively low force is required to open the poppet valve, hence decreasing fuel consumption. In other words, the load adjusting spring exerts a force onto the poppet valve which counteracts to the force which is exerted onto the poppet valve by the valve spring. It is noted that the valve spring and the load adjusting spring are different parts.

[0007] Preferably, the second portion of the load adjusting spring cooperates with the poppet valve such that

under operating conditions the spring force acts on the poppet valve at a location beyond the valve spring as seen from the spring seat, since this provides freedom of locating the load adjusting spring. The spring force may act on the poppet valve indirectly, for example through a rocker arm, where the spring force acts on the rocker arm and the rocker arm transfers the spring force onto the poppet valve.

[0008] In a particular embodiment the poppet valve is drivably coupled to the camshaft through an arm, wherein the arm is rotatably mounted on an adjusting shaft which is mounted to the engine block, wherein the second portion of the load adjusting spring engages the arm. Hence, the second portion of the load adjusting spring cooperates with the poppet valve via the arm. This provides freedom to locate the load adjusting spring at a distance from the poppet valve and the valve spring.

[0009] The second portion of the load adjusting spring may engage an upper side of the arm.

[0010] In an embodiment the arm is a rocker arm and the adjusting shaft is a rocker shaft.

[0011] The load adjusting spring may comprise a torsion spring of which the first portion is mounted to an adjusting wheel of the actuator which is rotatably mounted to the engine block.

[0012] Preferably, the adjusting wheel is mounted to the adjusting shaft, since this creates a compact structure.

[0013] The adjusting shaft may be mounted rotatably to the engine block, whereas the adjusting wheel is fixed to the adjusting shaft. In this case the first portion of the load adjusting spring may be fixed to the adjusting shaft.

[0014] The adjusting wheel may comprise a worm gear which is in engagement with a worm. The worm may be driven by an electric motor. In this case, the actuator comprises the worm, the worm gear and the electric motor.

[0015] The invention will hereafter be elucidated with reference to very schematic drawings showing embodiments of the invention by way of example.

Fig. 1 is a perspective view of a part of an embodiment of an internal combustion engine according to the invention.

Fig. 2 is a similar view as Fig. 1, but showing another embodiment.

Fig. 3 is a similar view as Fig. 1, but showing still another embodiment.

Fig. 4 is a similar view of the embodiment as shown in Fig. 3 as seen from a different side, in which parts are left out for explanatory reasons.

Fig. 5 is a similar view as Fig. 1, but showing another embodiment.

Fig. 6 is a similar view as Fig. 1, but showing still another embodiment.

[0016] Fig. 1 shows a part of an embodiment of an internal combustion engine 1 according to the invention. In this case the engine 1 has a single cylinder (not shown),

but the invention is also applicable to a multi-cylinder engine. The internal combustion engine 1 comprises a cylinder head 2 which is fixed to an engine block (not shown). Fig. 1 only shows a part of the cylinder head 2.

[0017] The engine 1 comprises intake and exhaust ports in the cylinder head 2. Each of the intake and exhaust ports is provided with a poppet valve 3 for opening and closing the intake and exhaust ports, respectively, in a well-known manner. Fig. 1 shows two poppet valves 3 at the respective intake ports of the cylinder of the engine 1. Each of the poppet valves 3 is slidably mounted to the cylinder head 2. At each of the poppet valves 3 an upper side of a valve spring 4 is mounted to a valve stem of the poppet valve 3 through a spring retainer 5, whereas a lower side of the valve spring 4 rests on a spring seat 6 of the cylinder head 2. The valve spring 4 is initially compressed at the time of installation such that the installed length of the valve spring 4 is less than its free length. Hence, the valve spring 4 always exerts a force on the poppet valve 3 in a direction to a position in which it closes the corresponding intake or exhaust port.

[0018] The poppet valves 3 are operated by a camshaft 7 which is rotatably mounted to the cylinder head 2. In the embodiment as shown in Fig. 1 the poppet valves 3 are drivably coupled to the camshaft 7 through respective arms 8 which are rotatably mounted on an adjusting shaft 9.

[0019] The adjusting shaft 9 is rotatably mounted to the cylinder head 2 and provided with an adjusting wheel in the form of a worm gear 10. The worm gear 10 is fixed to the adjusting shaft 9 and meshes with a worm 11. The worm 11 is fixed to an output shaft of an electric motor 12. The adjusting shaft 9 is fixed to respective first portions 13 of respective load adjusting springs 14. The load adjusting springs 14 are partly torsion springs which surround the adjusting shaft 9. The load adjusting springs 14 have respective second portions 15 which are located at a distance from the respective first portions 13. The second portions 15 of the load adjusting springs 14 engage the respective arms 8 at lateral projections thereof. In the embodiment as shown in Fig. 1 each arm 8 is engaged by two load adjusting springs 14, but it is also conceivable that only one load adjusting spring 14 or more than two load adjusting springs 14 engage a single arm 8.

[0020] The electric motor 12, the worm 11, the worm gear 10 and the adjusting shaft 9 form part of an actuator for rotating the respective first portions 13 of the load adjusting springs 14 with respect to the cylinder head 2. Turning the respective first portions 13 of the load adjusting springs 14 leads to varying spring forces on the respective arms 8 exerted by the second portions 15. Consequently, this creates different forces on the respective poppet valves 3, in opposite direction than the direction in which the valve springs 4 exert respective forces on the poppet valves 3. This means that the electric motor 12 can be operated such that, for example at low engine speed, the forces of the load adjusting springs 14 on the

corresponding poppet valves 3 act in a direction which is the same as the forces of the arms 8 onto the poppet valves 3 upon opening the valves 3 when there were no load adjusting springs 14. As a result, the total forces required to open the poppet valves 3 by the camshaft 7 are reduced, resulting in lower fuel consumption of the internal combustion engine 1.

[0021] Fig. 1 shows that the second portions 15 of each pair of load adjusting springs 14 cooperate with the corresponding poppet valve 3 such that under operating conditions the spring forces of the load adjusting springs 14 act indirectly via the corresponding arm 8 on the top of the poppet valve 3, i.e. at a location beyond the valve spring 4 as seen from the spring seat 6.

[0022] Fig. 2 shows another embodiment. Parts in this embodiment which have the same function as parts in the embodiment as shown in Fig. 1 have corresponding reference signs. The embodiment of the internal combustion engine 1 as shown in Fig. 2 has hydraulic valve lifters 16. The second portions 15 of the load adjusting springs 14 rest on top of the respective hydraulic valve lifters 16 and work in a similar way as in the embodiment of Fig. 1.

[0023] Figs. 3 and 4 show still another embodiment as seen from different sides, respectively. Parts in this embodiment which have the same function as parts in the embodiments as shown in Figs. 1 and 2 have corresponding reference signs. In Fig. 4 the cylinder head 2 is left out for explanatory reasons. In this embodiment the camshaft 7 operates poppet valves (not shown) at an inlet port and an outlet port, respectively, through respective rocker arms 17. The rocker arms 17 are rotatably mounted on the adjusting shafts 9, which may also be called rocker shafts in this case. The load adjusting springs 14 engage the respective rocker arms 17. Hence, each of the adjusting shafts 9 has two functions: it changes the spring force of the load adjusting spring 14 upon rotation of the adjusting shaft 9 with respect to the engine block and it supports the rocker arm 17. The worm gears 10 of the respective adjusting shafts 8 mesh with the worm 11 such that they rotate synchronously in opposite directions upon turning the worm 11. The load adjusting springs 14 are mounted to the respective adjusting shafts 8 and the respective rocker arms 17 such that a pushing force of their second portions 15 onto the respective poppet valves 3 varies upon rotating the worm 11.

[0024] Fig. 5 shows still another embodiment. Parts in this embodiment which have the same function as parts in the embodiments as shown in Figs. 1-4 have corresponding reference signs. In this case the load adjusting springs 14 also engage the respective rocker arms 17 but they have a partly spiral shape. The first portions 13 of the load adjusting springs 14 may be fixed to the respective adjusting shafts 9 or the respective worm gears 10.

[0025] Fig. 6 shows still another embodiment. Parts in this embodiment which have the same function as parts in the embodiments as shown in Figs. 1-5 have corre-

sponding reference signs. This embodiment has a lot of similarities as the embodiment shown in Figs. 3 and 4, but the location of the worm 11 and electric motor 12 is different. The worm 11 meshes with one worm gear 10 which is mounted to the corresponding adjusting shaft 9 together with an auxiliary gear 18 which is located at an opposite end of the corresponding adjusting shaft 9, whereas the auxiliary gear 18 meshes with the gear 10 that is mounted to the other adjusting shaft 9. Although the configurations of the embodiments as shown in Fig. 6 and in Figs. 3 and 4 are different, they function in a similar way.

[0026] The invention is not limited to the embodiments shown in the drawings and described hereinbefore, which may be varied in different manners within the scope of the claims and their technical equivalents. The load adjusting spring may also be a different spring type, for example a helical spring.

Claims

1. An internal combustion engine (1) comprising an engine block (2), a poppet valve (3) which is slidably mounted to the engine block (2), a camshaft (7) for operating the poppet valve (3) which camshaft (7) is rotatably mounted to the engine block (2), a valve spring (4) which is fixed to the poppet valve (3) and resting on a spring seat (6) of the engine block (2), a load adjusting spring (14) for exerting a spring force on the poppet valve (3), **characterized in that** the load adjusting spring (14) has a first portion (13) which cooperates with an actuator (9-12) for displacing the first portion (13) with respect to the spring seat (6) and a second portion (15) located at a distance from the first portion (13), which second portion (15) cooperates with the poppet valve (3).
2. An internal combustion engine (1) according to claim 1, wherein the second portion (15) of the load adjusting spring (14) cooperates with the poppet valve (3) such that under operating conditions the spring force acts on the poppet valve (3) at a location beyond the valve spring (4) as seen from the spring seat (6).
3. An internal combustion engine (1) according to claim 2, wherein the poppet valve (3) is drivably coupled to the camshaft (7) through an arm (8, 17), wherein the arm (8, 17) is rotatably mounted on an adjusting shaft (9) which is mounted to the engine block (2), wherein the second portion (15) of the load adjusting spring (14) engages the arm (8, 17).
4. An internal combustion engine (1) according to claim 3, wherein the second portion (15) of the load adjusting spring (14) engages an upper side of the arm (8, 17).
5. An internal combustion engine (1) according to claim 3 or 4, wherein the arm is a rocker arm (17) and the adjusting shaft is a rocker shaft (9).
6. An internal combustion engine (1) according to one of the preceding claims, wherein the load adjusting spring (14) comprises a torsion spring of which the first portion (13) is mounted to an adjusting wheel (10) of the actuator (9-12) which is rotatably mounted to the engine block (2).
7. An internal combustion engine (1) according to claim 6 and to one of the claims 3-5, wherein the adjusting wheel (10) is mounted to the adjusting shaft (9).
8. An internal combustion engine (1) according to claim 7, wherein the adjusting shaft (9) is mounted rotatably to the engine block (2) and the adjusting wheel (10) is fixed to the adjusting shaft (9).
9. An internal combustion engine (1) according to one of the claims 6-8, wherein the adjusting wheel (10) comprises a worm gear which is in engagement with a worm (11).

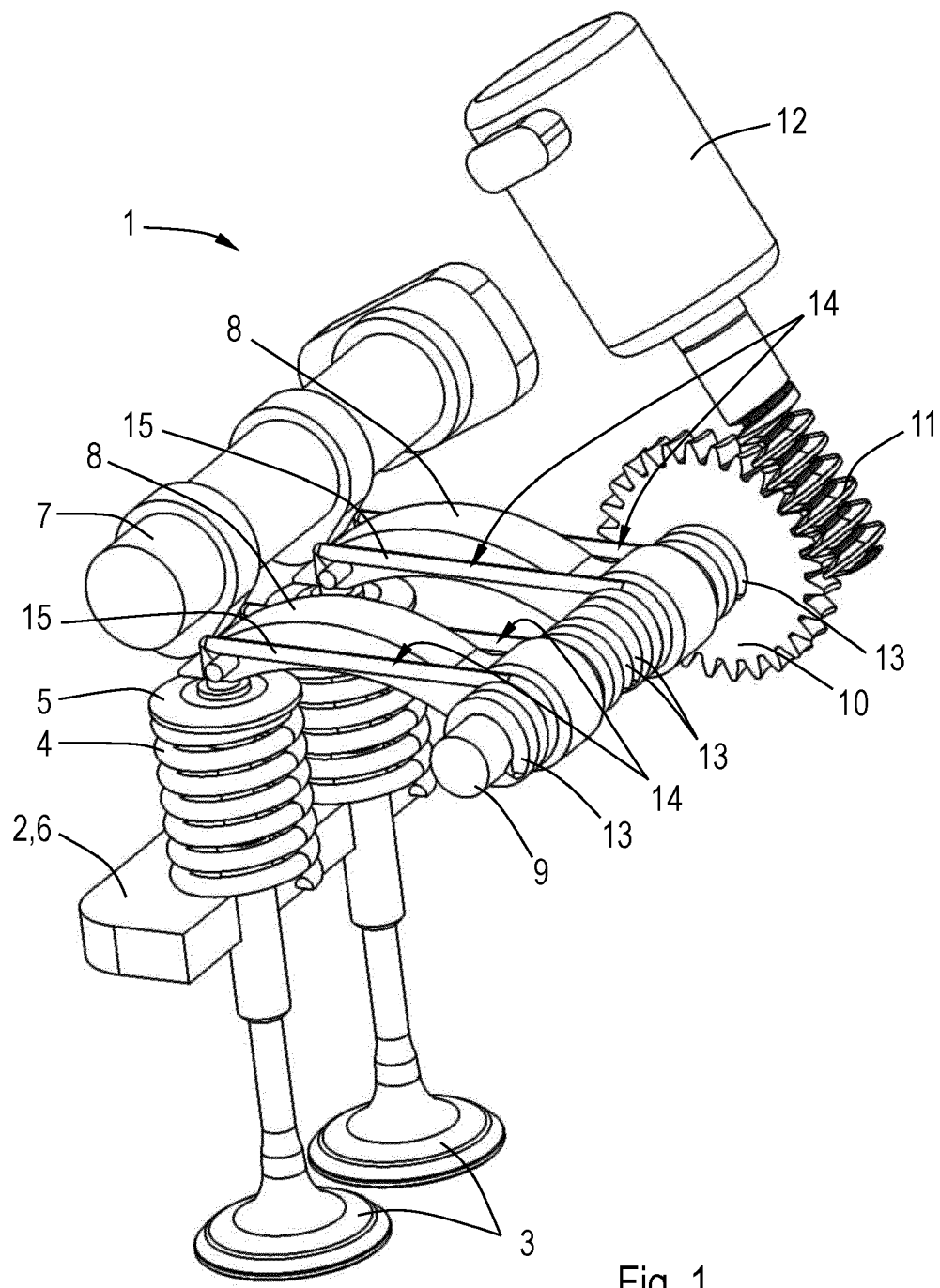


Fig. 1

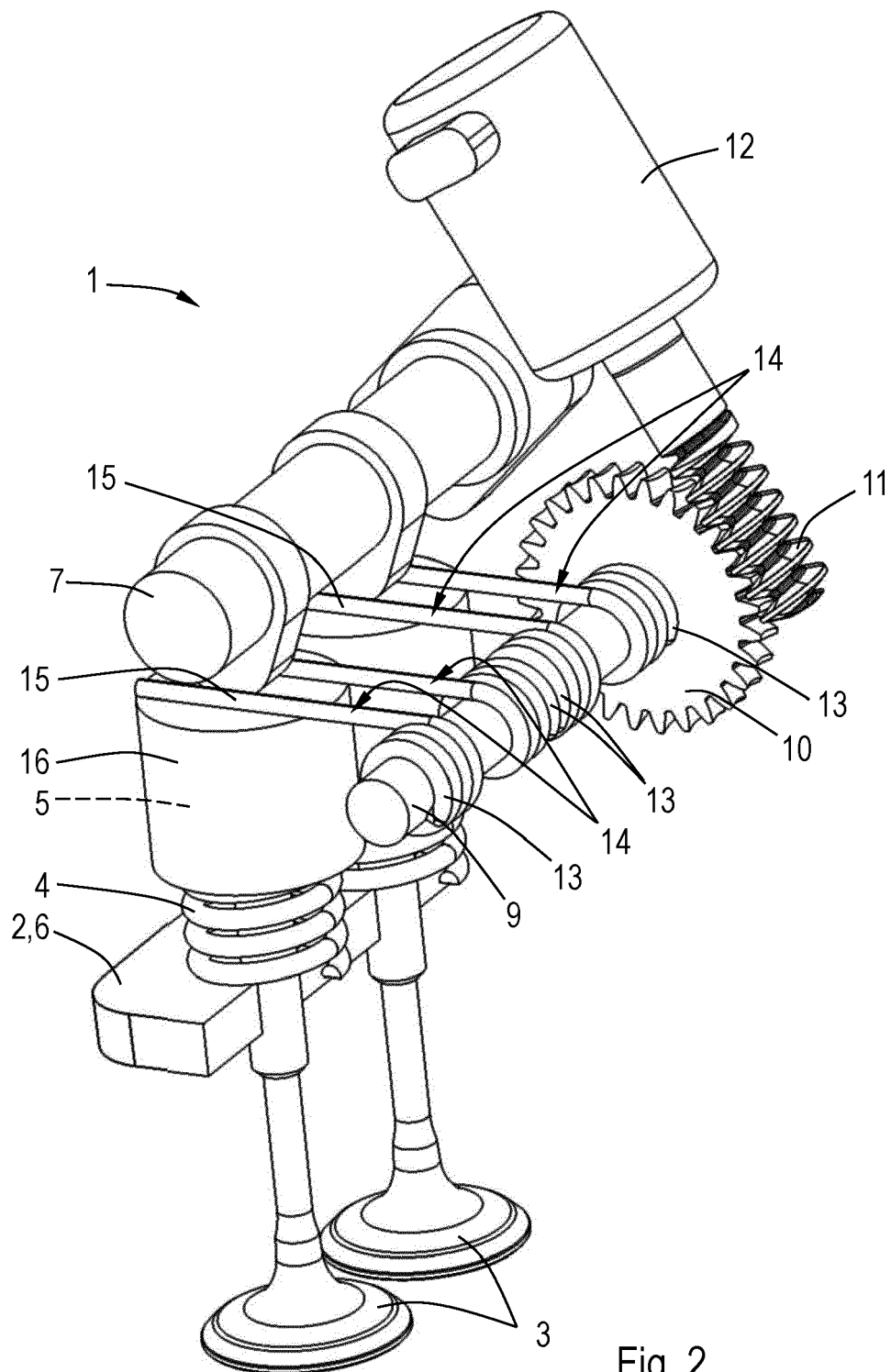


Fig. 2

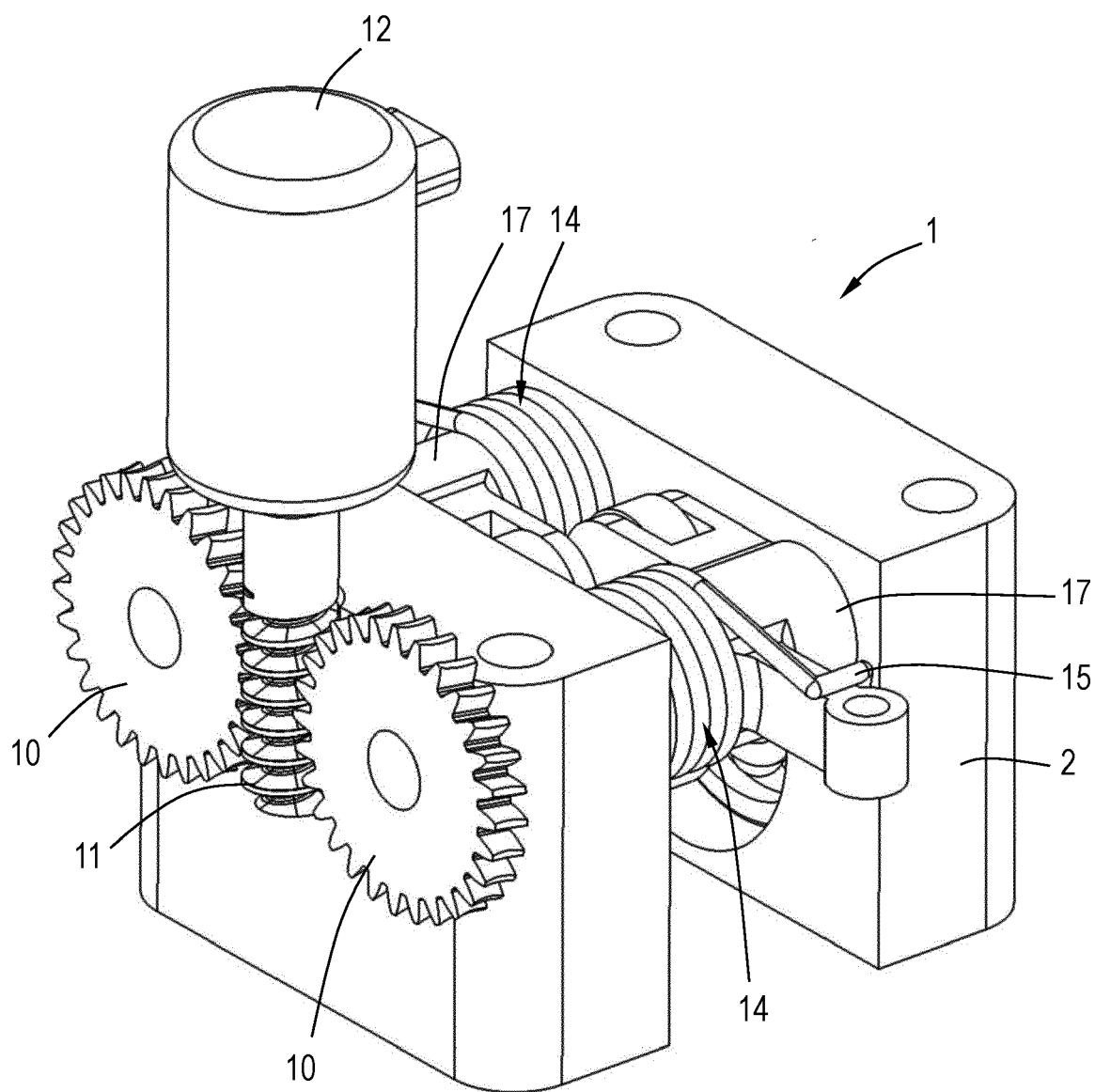


Fig. 3

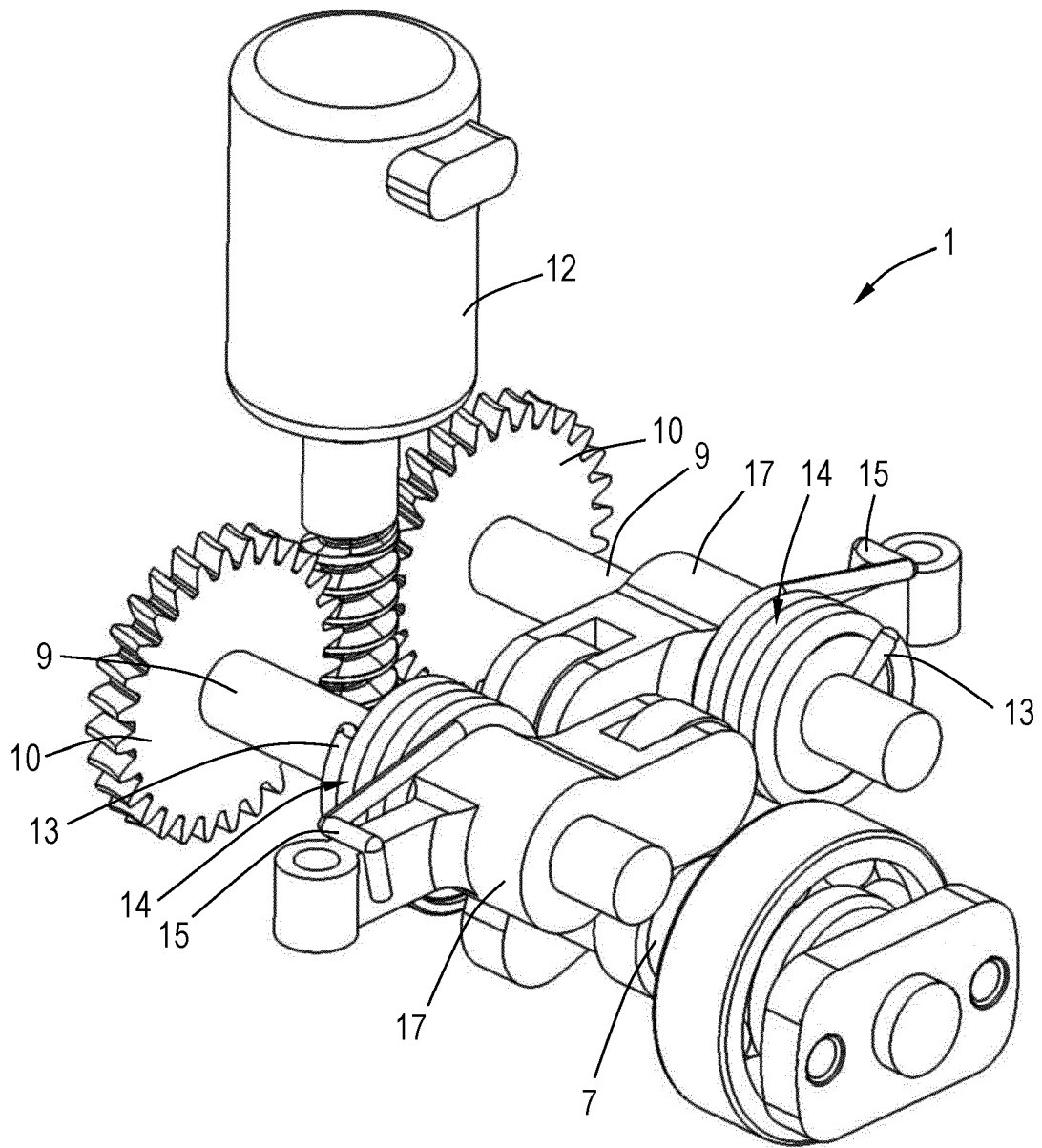


Fig. 4

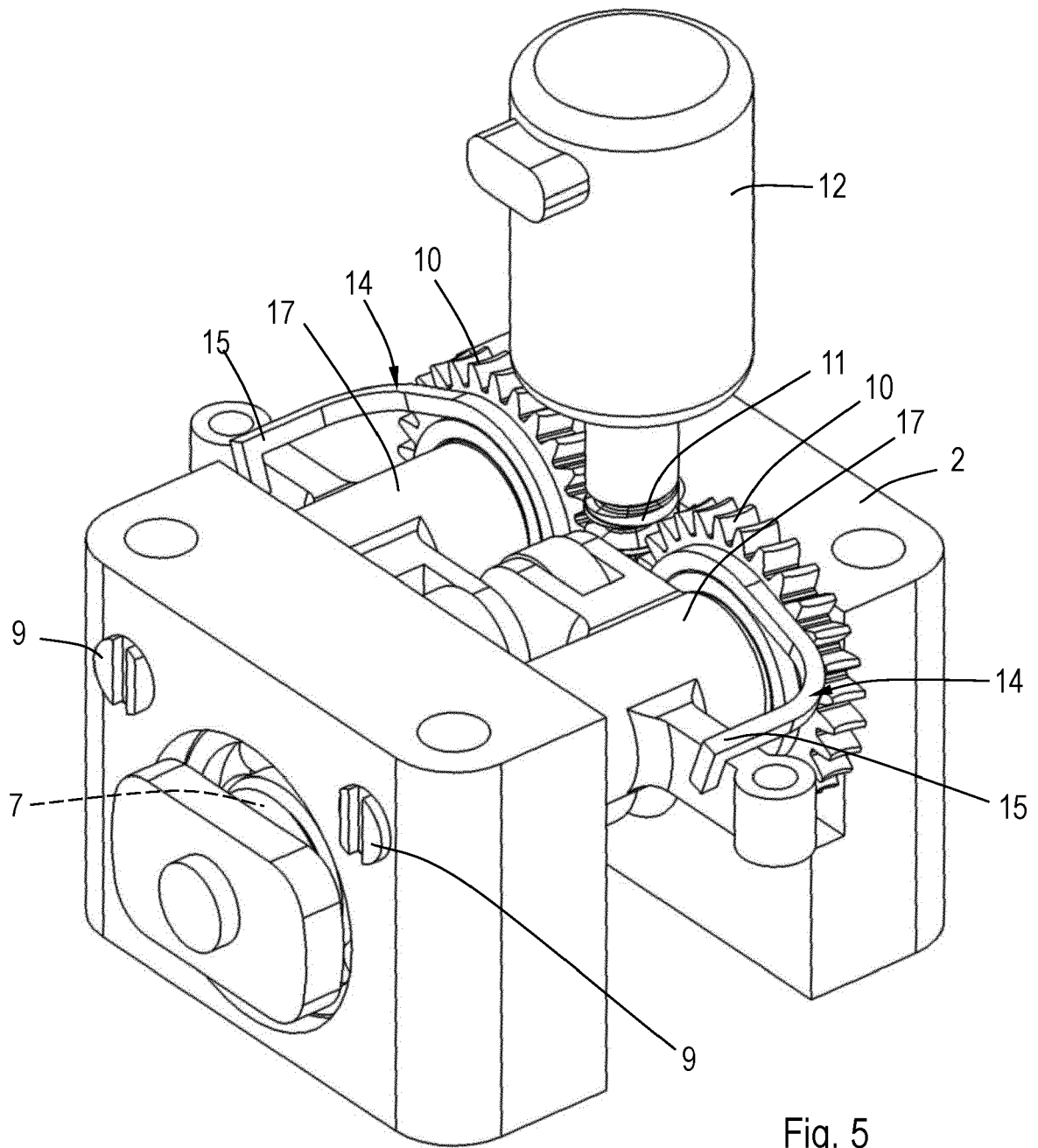
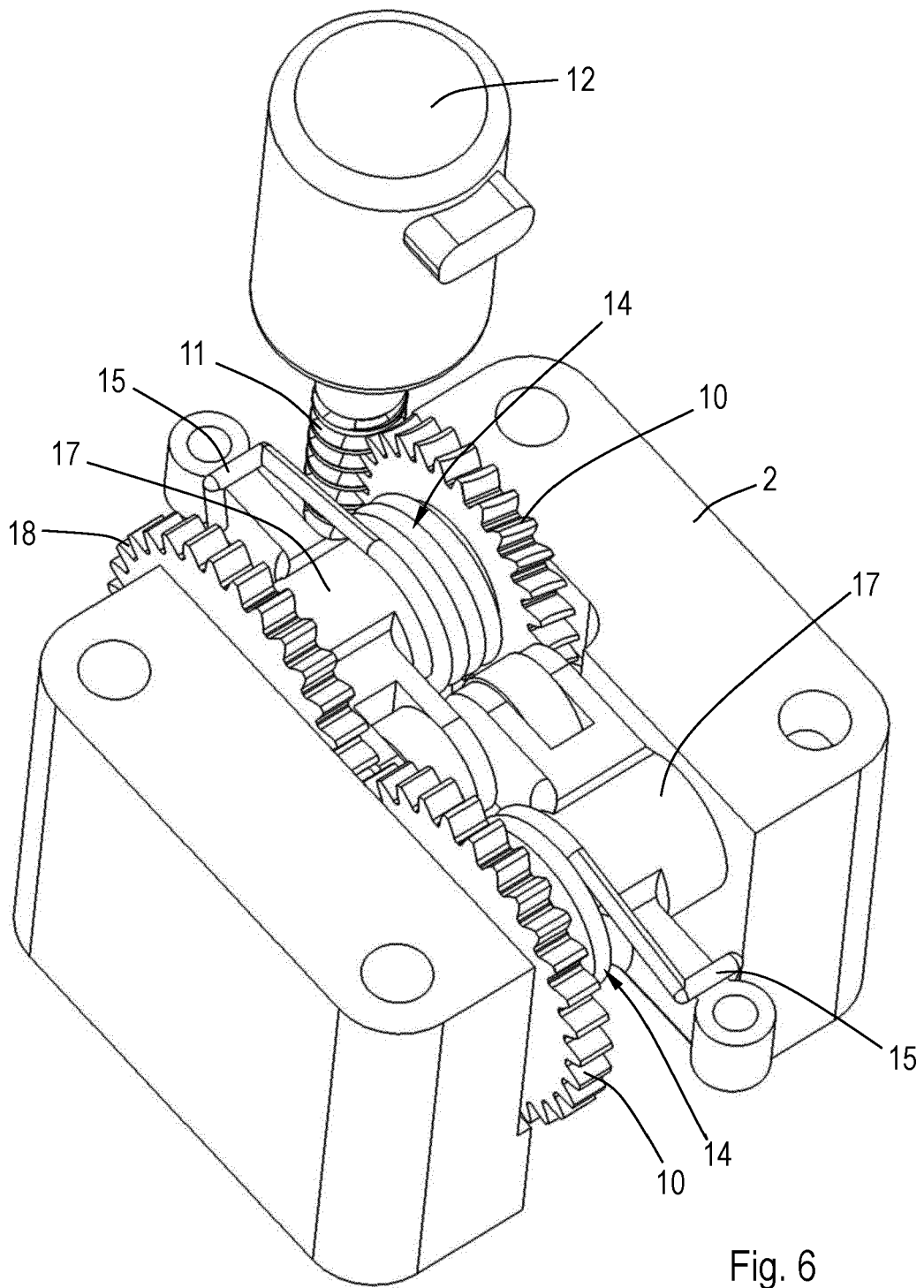


Fig. 5





EUROPEAN SEARCH REPORT

Application Number

EP 21 18 6617

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EPO FORM 1503 03.82 (P04C01)

DOCUMENTS CONSIDERED TO BE RELEVANT			
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A	* abstract; figure 1 * * paragraph [0001] * * paragraph [0007] *	7-9	F01L3/10 F01L1/18

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A	* abstract; figure 1 * * column 3, line 65 - column 4, line 45 *	7-9	

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A	* abstract; figures 1,2 * * page 3 * * page 6 *	7-9	

			TECHNICAL FIELDS SEARCHED (IPC)
			F01L
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 14 December 2021	Examiner Van der Staay, Frank
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 21 18 6617

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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14-12-2021

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REFERENCES CITED IN THE DESCRIPTION

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