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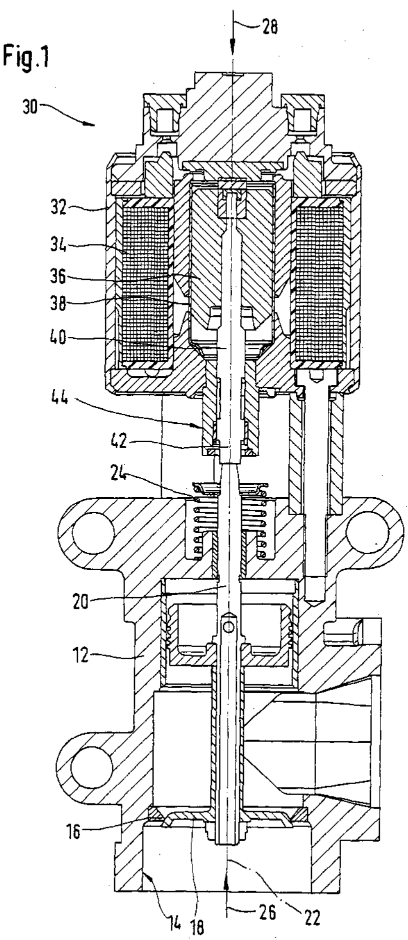
(54) Exhaust gas recirculation valve for an internal combustion engine

(57) An exhaust gas recirculation valve (10) for an internal combustion engine comprises a valve seat (16) and a closing element (18) associated with the valve seat. A spring means (24) is associated with the closing element so as to bias the closing element on its valve seat. An actuating means (20,30,40) is connected to the closing element for moving the closing element in an opening direction. An override catch means (44) is associated with the actuating means for retaining the closing element in an open park position. The override catch means is activated by the actuating means when the latter moves the closing element from the closed position in the opening direction beyond an override position. The override catch means is deactivated by the actuating means when the latter moves the closing element out of its park position in the opening direction.

Fig.1



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Description

Field of the invention

[0001] The present invention generally relates to an exhaust gas recirculation valve for an internal combustion engine.

Background of the invention

[0002] In internal combustion engines exhaust gas recirculation valves are used to regulate the proportion of combustion gas that is recirculated into an intake air manifold. A known problem of such valves is that the seat is always covered with soot and other deposits and there is a high risk that the valve disk firmly sticks to its seat if the valve remains closed for some time, which may impede the opening of the valve.

[0003] A solution to this problem is provided by DE-A-198 25 583, which relates to an exhaust gas recirculation valve for an internal combustion engine comprising a valve seat and a closing element associated thereto. The closing element has a valve stem, which is connected to an electrical actuator, comprising e.g. an electrical motor. The electrical actuator is capable of moving the closing element in a closing direction towards the valve seat, so as to bring the closing element in its closed position, and also permits to move the closing element in an opposite, opening direction, so as to regulate the proportion of recirculated exhaust gas. An opening spring is arranged about the valve stem in such a way as to exert a force on the valve stem in the opening direction, which is sufficient to maintain the closing element in a slightly open position when the actuator is not energized. It follows that, when the engine is turned off, i.e. no electricity is supplied to the actuator, the closing element is moved into an open position. Although such a solution is effective for preventing the sticking of the closing element to its valve seat, the exhaust gas recirculation valve of DE-A-198 25 583 has the drawback that it must be equipped with an actuator that is capable of exerting actuating forces in two directions in order to be able to close and open the valve.

Object of the invention

[0004] The object of the present invention is to provide an exhaust gas recirculation valve in which the closing element can be maintained in an open park position when the actuator of the valve is not energized, without having to use a bi-directional valve actuator. This object is solved by an exhaust gas recirculation valve as claimed in claim 1.

Summary of the invention

[0005] An exhaust gas recirculation valve for an internal combustion engine in accordance with the invention comprises a valve seat and a closing element associated with this valve seat. A spring means is associated with the closing element so as to bias the latter on its valve seat. Actuating means are connected to the closing element for moving the closing element in an opening direction. It shall be appreciated that override catch means are associated with the actuating means for retaining the closing element in an open park position. The override catch means are activated by the actuating means when the latter moves the closing element from its closed position in the opening direction beyond an override position. The deactivation of the override catch means occurs when the actuating means moves the closing element out of its park position in the opening direction.

[0006] Due to the spring means, the closing element is permanently pushed towards its valve seat. This means that when the override catch means are not activated and no force is exerted on the closing element by the actuating means, the closing element rests on its valve seat, i.e. the valve is closed. Hence, to operate the valve, it suffices that the actuating means be capable of exerting a force in the opening direction so as to move the closing element in an open position. Moreover, the override catch means is activated or deactivated by movements of the actuating means in the opening direction. It follows that the actuating means used in the valve of the invention only has to be capable of exerting a force on the closing element in the opening direction. Generally, the valve is operated as follows. When the engine is running, the closing element can be moved between its closed position and the override position in order to control the proportion of recirculated exhaust gas. When the engine is turned off, the closing element is moved in the opening direction beyond the override position, so as to activate the override catch means, which is a mechanical system and does not require energy to be active. As a result, the closing element is retained in the park position when the engine is not running, thereby avoiding the sticking problem of the closing element on the valve seat. When turning the engine on, the actuating means is operated in such a way as to move the closing element in the opening direction out of the park position to deactivate the override catch means.

[0007] It will be understood that, above its mechanical structure, the override catch means should be considered as a mechanism, which is activated by the actuating means when the closing element is moved beyond the override position, and which is deactivated by a movement of the actuator in the opening direction. Such mechanisms are frequently used in retractable pens, and can be adapted to be incorporated in an exhaust gas recirculation valve. The incorporation of override catch means in exhaust gas recirculation valves is a simple and cheap way of overcoming the problems of sticking of the closing element on its valve seat.

[0008] The override catch means preferably comprises a rotating part interacting with the actuating means by means of a cam mechanism so that the actuating means rotates the rotating part between a first angular position, in which it retains the closing element in the open park position, and a second angular position, in which it releases said closing element out of its open park position.

[0009] In a first embodiment, the actuating means comprises an axially movable shaft comprising a pair of protruding elements. The rotating part is an axially immobile ring capable of rotating about the shaft. The ring comprises cam-profile means interacting with the pair of protruding elements to rotate the ring about the shaft and to define the park position.

[0010] In a second embodiment, the override catch means comprises a bushing and the actuating means comprises a shaft axially movable in the bushing. The rotating part is a ball guided in a first groove located in the bushing and a second groove located in the shaft. For example, one of the grooves may be an annular groove with a plane of symmetry perpendicular to the axis of the shaft. The other groove is then a closed loop groove defining two axially spaced stop surfaces.

[0011] Advantageously, the actuating means comprises an actuator for generating an opening force as well as an actuating shaft slideably mounted in the actuator for transmitting the opening force. Such an actuator is preferably a linear solenoid actuator, as it provides a quick response time and an accurate position control.

[0012] It will be understood that the override catch means can be designed so as to interact with any part of the actuating means, provided that this part is moved in correspondence with the closing element. The actuating means may thus be designed so as to interact e. g. with an actuating shaft of an actuator or with a valve shaft in the valve body.

Brief description of the drawings

[0013] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig.1: is a cross-sectional view of a preferred embodiment of an exhaust gas recirculation valve according to the invention;

Fig.2: is a view in perspective of the unassembled override catch means of the valve of Fig.1;

Fig.3: is a partial cutaway view of the ring of Fig.2;

Fig.4: is a schematic view of the actuating shaft of Fig.1 in its rest position and of the corresponding position of the ring;

Fig.5: is a schematic view of the actuating shaft of Fig.1 in the override position and of the corresponding position of the ring;

Fig.6: is a schematic view of the actuating shaft of Fig.1 in a retained position (i.e. an open park position) and of the corresponding position of the ring;

Fig.7: is a schematic view of the release of the actuating shaft of Fig.1 and of the corresponding position of the ring;

Fig.8: is a schematic view of another override catch means, with the shaft in its rest position;

Fig.9: is a schematic view of the override catch means of Fig.2, with the shaft in an intermediate position; and

Fig.10: : is a schematic view of the override catch means of Fig.2, with the shaft in its park position.

[0014] In the Figures, same reference numbers indicate similar or equivalent elements.

Detailed description of a preferred embodiment

[0015] Fig.1 shows a preferred embodiment of an exhaust gas recirculation valve 10 in accordance with the invention. The valve 10 comprises a valve body 12 with a valve passage 14, which is intended to provide a communication between an exhaust gas duct and an air intake manifold. A valve seat 16 is arranged in this valve passage 14 and has an associated closing element 18 so as to selectively close or open the passage 14. The closing element 18 is connected to a valve shaft 20 mounted in the valve body 12 so as to be slideable about an axis 22. The valve shaft 20 protrudes out of the upper part of the valve body 12. In this region, a closing spring 24 is connected between the valve body 12 and the valve shaft 20 so as to bias the valve shaft in the direction of arrow 26, and to press the closing element 18 on its seat 16 when no force is exerted on the valve shaft 20, the arrow 22 thus indicating the closing direction. It follows that, in order to open the valve 10, a force has to be exerted on the valve shaft 20 in the opposite direction of arrow 28 (i.e. the opening direction) so as to overcome the elastic force of the closing spring 24.

[0016] A linear solenoid actuator, generally indicated 30, is mounted to the valve body 12 for actuating the closing element 18 via the valve shaft 20. The actuator comprises an iron frame 32, in which an annular solenoid 34 is mounted. The iron frame 32 surrounds the solenoid 34 and includes magnetic pole pieces defining within the solenoid a cylindrical chamber for a plunger 36. The latter is a cylindrical iron body that is axially guided in a metallic guide sleeve 38. An actuating shaft 40, centrally received and fixed in the plunger 36, is aligned with the valve axis 22 and has its lower part protruding out of the actuator frame 32 towards the valve body 12. The actuating shaft 40 ends by a preferably enlarged portion 42 having a larger diameter than the central part of the actuating shaft 40. The end face of this enlarged portion 42 bears against the upper end of the valve shaft 20. When the solenoid 34 is energized, the iron plunger 36 is magnetized and moves in its guide sleeve 38 in the opening direction (arrow 28), by virtue of the magnetic attraction between it and the magnetic pole pieces of the iron frame 34. The actuating shaft 40 is thus moved in the opening direction and exerts an opening force in the opening direction on the valve shaft 20, thereby moving the closing element in the opening direction. It follows that the position of the closing element 18 is controlled by the position of the actuating shaft 40.

[0017] In accordance with an important aspect of the invention, an override catch means, generally indicated 44, is associated with the actuating shaft 40 for retaining the closing element 18 in an open park position. The override catch means 44 is preferably arranged at the level of the lower part of the actuating shaft 40. For clarity of understanding, the actuating shaft 40 and the different elements of the override catch means 44 are individually shown in Fig.2. The override catch means 44 includes oblong ribs 46, 48 protruding on the surface of the actuating shaft 40 and which extend parallel to the axis of the actuating shaft 40. In this embodiment, four such ribs are provided, however more ribs can be provided. The ribs are located at the level of the lower part of the actuating shaft 40 and extend radially. They are always arranged in pairs and have the following geometric configuration. The lower rib 48, close to the enlarged portion 42, is arranged so as to extend over a predetermined axial length starting approximately from the enlarged portion 42. The other, upper rib 46, distal from the enlarged portion 42, is spaced in axial direction by a distance h (see Fig.4) from the lower rib 48, so that a portion of the outer surface of the actuating shaft 40 remains without ribs in axial direction between the ends of the two ribs 46, 48 which face each other.

[0018] In addition, the two ribs 46, 48 are offset to each other in circumferential direction, so that one side 50 of one rib 46 is in alignment with the other side 52 of the other rib 48, the two ribs 46, 48 hence being located immediately next to one another when viewed in axial direction. If a plurality of such ribs are provided, they are uniformly distributed over the circumference and all are offset in the same direction.

[0019] Moreover, the override catch means 44 includes a ring 54 provided with cam-profile means so as to interact with the ribs 46, 48 on the actuating shaft 40, as will be further detailed. The ring 54 is mounted about the lower part of the shaft 40, at the level of the ribs 46, 48. The override catch means 44 also includes a bushing 56 fixed to the actuator frame 32, in which the actuating shaft 40 is capable of sliding and the ring 54 is axially immobilized. The ring 54 is however allowed to rotate about the actuating shaft 40 in the bushing 56. A washer 58 closes the lower part of the bushing 56.

[0020] In Fig.3, the ring 54 is shown in an enlarged view and a part of the ring 54 has been cut out to show the cam-profile means provided on its inner side. This cam-profile means, which includes axial grooves and saw-toothings, is designed in such a way that the manner of operation described further below is possible. In this embodiment, two pairs of ribs 46, 48 are provided. The ring 54 has four axial grooves 60. The ring is provided at each of its two end faces with saw-toothings 62, 64, the latter being arranged between the grooves 60. Each saw-toothing 62, 64 comprises a long and a short tooth. The inclination of the toothings 62, 64 are aligned in the same direction. The axial distance of the ring 54 between the tips of the teeth, i.e. the height H (see Fig. 5), is approximately equal to the axial distance h between the two ends of the corresponding ribs 46, 48 which face each other; the axial distance between the bases of the teeth being smaller than h.

[0021] The above described measures make it possible for the ring 54 to be rotated in the ribless portion of the actuating shaft 40 if it is subjected to a reciprocating axial movement of the actuating shaft 40, so as to define different angular positions, and especially angular positions in which the closing element 18 is allowed to be retained in the open park position.

[0022] The manner of operation of the override catch means 44 will be now explained in detail with respect to Fig.4-7. The position of the actuating shaft 40 with respect to the bushing 56 is illustrated in the upper part of each of these Figures; and the corresponding interaction between the cam-means of the ring 54 and the ribs 46, 48 is illustrated in the lower part. The position of the actuating shaft 40 in the bushing 56 is representative of its position in the actuator frame 32 as the bushing 56 is fixed therein.

[0023] In Fig.4 the actuating shaft 44 is in its rest position. The solenoid 34 is not energized and no force is exerted on the valve shaft 20, the closing element 18 thus rests on its valve seat 16 and the valve 10 is closed. The lower rib 48 is in the axial groove 60. The ring 54 is in an angular position θ_0.

[0024] When the solenoid 34 is energized, the actuating shaft 40 is moved in the opening direction (downward arrow in Fig.5) and the lower rib 48 axially slides in the groove 60. As a result, the valve shaft 20 follows the movement of the actuating shaft 40 and the closing element 18 is moved in the opening direction. The valve 10 is opened and exhaust gas is allowed to flow into the intake manifold.

[0025] In Fig.5, the actuating shaft 40 has been moved to a so-called override position, to which an override position of the closing element corresponds. It shall be noted that moving the actuating shaft, and thus the closing element beyond this override position activates the override catch means. In other words, as long as the closing element 18 is moved between its closed position and the override position the ring remains in the angular position θ_0 and the override catch means 44 remains inactive. Hence, the closing element 18 returns to its closed position when the solenoid 34 is switched off. The working travel of the actuating shaft 40 for controlling the proportion of recirculated exhaust gas is indicated by letter T in Fig.5.

[0026] Now, when the actuating shaft 40 is further moved in the opening direction, i.e. beyond the override position, the upper rib 46 contacts the long tooth of the toothing 62 with which it is axially aligned. The ring 54 is thus rotated in the direction of the horizontal arrow in Fig.5, until the upper rib 46 meets the base of the toothing 62. In this position, the lower rib 48 faces the long tooth of the toothing 64. Hence, when the solenoid 34 is switched off, the actuating shaft 40 is allowed to move in the closing direction but only for a distance needed for the lower rib 48 to be caught in the basis of the toothing 64. This again causes the rotation of the ring 54 in the direction of the arrow in Fig.6 so that the ring 54 is moved to another angular position θp. This position in which the lower rib 48 is blocked in the basis of the toothing 64 is called park position. In this "active mode" of the override catch means 44, the closing element 18 is retained in an open park position without using any electrical energy, thereby avoiding sticking problems of the closing element 18 onto its valve seat 16 due to soot and other deposits thereon. The closing element 18 will advantageously be moved beyond the override position when the engine is turned off so as to activate the override catch means 44.

[0027] The release of the actuating shaft 40, and hence of the closing element 18, from this park position is effected by moving the actuating shaft 40 by means of the solenoid 34 in the opening direction. This causes the disengagement of the lower rib 48 from the basis of the toothing 64 and causes the upper rib 46, which then faces the short tooth of the toothing 62, to meet this toothing so as to rotate the ring 54 and then engage the next groove 60'. At this point, switching off the solenoid 34 causes the upper rib 46 to be disengaged from the groove 60 and the lower rib 48 to meet the short tooth of the toothing 64 so that it rotates the ring 54 to a further angular position θr, in which it engages the groove 60'. As a result, the override catch means 44 is deactivated and the actuating shaft 40 is allowed to return in its rest position, shown in Fig.4. This procedure is to be carried out when the engine is turned on so as to release the closing element 18 from its park position. When the lower rib 48 is in the groove 60 (the ring 54 being in the angular position θr) the configuration of the override catch means 44 is similar to that shown in Fig.4. It follows that the override catch means 44 is ready for a similar operating cycle.

[0028] Another kind of override catch means 100 is illustrated in different positions in Figures 8 to 10. This override catch means 100 comprises a bushing 102 and a shaft 104 axially movable in the bushing 102. A spring (not shown) is arranged so as to bias the shaft 104 in the upward direction, indicated by the arrow in Fig.8. The bushing 102 has an annular groove 106 that is transversally arranged with respect to the axis of the shaft 114. A heart-shaped groove 108 is provided at the surface of the shaft 104. It shall be noted that a steel ball 110 is simultaneously guided in both grooves 106 and 108. When no actuating force is exerted on the shaft in the opposite direction of the arrow in Fig.8, the axially immovable ball 110 rests against a lower stop surface 112 of the shaft groove 108, which determines a rest position of the shaft 104.

[0029] Now, if an actuating force is exerted on the shaft 104, the latter moves downward and the ball 110 moves in the annular groove 106 so as to follow the hearth-shaped groove 108 in the clockwise direction. The ball 110 then meets a first recess 114 in the groove 108 so that the movement of the shaft 104 is stopped, as shown in Fig.9. When the actuating force is suppressed, the spring force causes the ball 110 to be guided to an upper stop surface 116, as illustrated in Fig.10. This is the park position of the shaft 110.

[0030] The release of the shaft 104 out of its park position is effected by exerting a downward force on the shaft 104 so that the ball 110 is guided in a second recess 118. In this position, the suppression of the downward force causes the shaft 104 to be moved axially by the spring and thus the ball 110 to be guided in the hearth-shaped groove 108 to the lower stop surface 112.

Claims

1. An exhaust gas recirculation valve for an internal combustion engine comprising:

    a valve seat;

    a closing element associated with said valve seat;

    a spring means associated with said closing element so as to bias said closing element on its valve seat;

    actuating means connected to said closing element for moving said closing element in an opening direction;

    characterized by
    override catch means associated with said actuating means for retaining said closing element in an open park position, said override catch means being activated by said actuating means when the latter moves said closing element from said closed position in said opening direction beyond an override position, and said override catch means being deactivated by said actuating means when the latter moves said closing element out of its park position in said opening direction.

2. The exhaust gas recirculation valve of claim 1, **characterized in that** said override catch means comprises:

a rotating part interacting with said actuating means by means of a cam mechanism, so that said actuating means rotates said rotating part between a first angular position, in which it retains said closing element in said open park position, and a second angular position, in which it releases said closing element out of its open park position.

3. The exhaust gas recirculation valve of claim 2, **characterized in that**
said actuating means comprises an axially movable shaft comprising a pair of protruding elements; and said rotating part is an axially immobile ring capable of rotating about said shaft, said ring comprising cam-profile means interacting with said pair of protruding elements to rotate said ring about said shaft and to define said park position.

4. The exhaust gas recirculation valve of claim 2, **characterized in that**

said override catch means comprises a bushing;

said actuating means comprises a shaft axially movable in said bushing; and

said rotating part is a ball guided in a first groove located in said bushing and a second groove located in said shaft.

5. The exhaust gas recirculation valve of claim 4, **characterized in that**

one of said grooves is an annular groove with a plane of symmetry perpendicular to the axis said shaft; and

the other groove is a closed loop groove defining two axially spaced stop surfaces.

6. The exhaust gas recirculation valve as claimed in any one of claims 1 to 5, **characterized in that** said actuating means comprises an actuator for generating an opening force and an actuating shaft slideably mounted in said actuator for transmitting said opening force .

7. The exhaust gas recirculation valve of claim 4, **characterized in that** said actuator is a linear solenoid actuator.

Fig.1

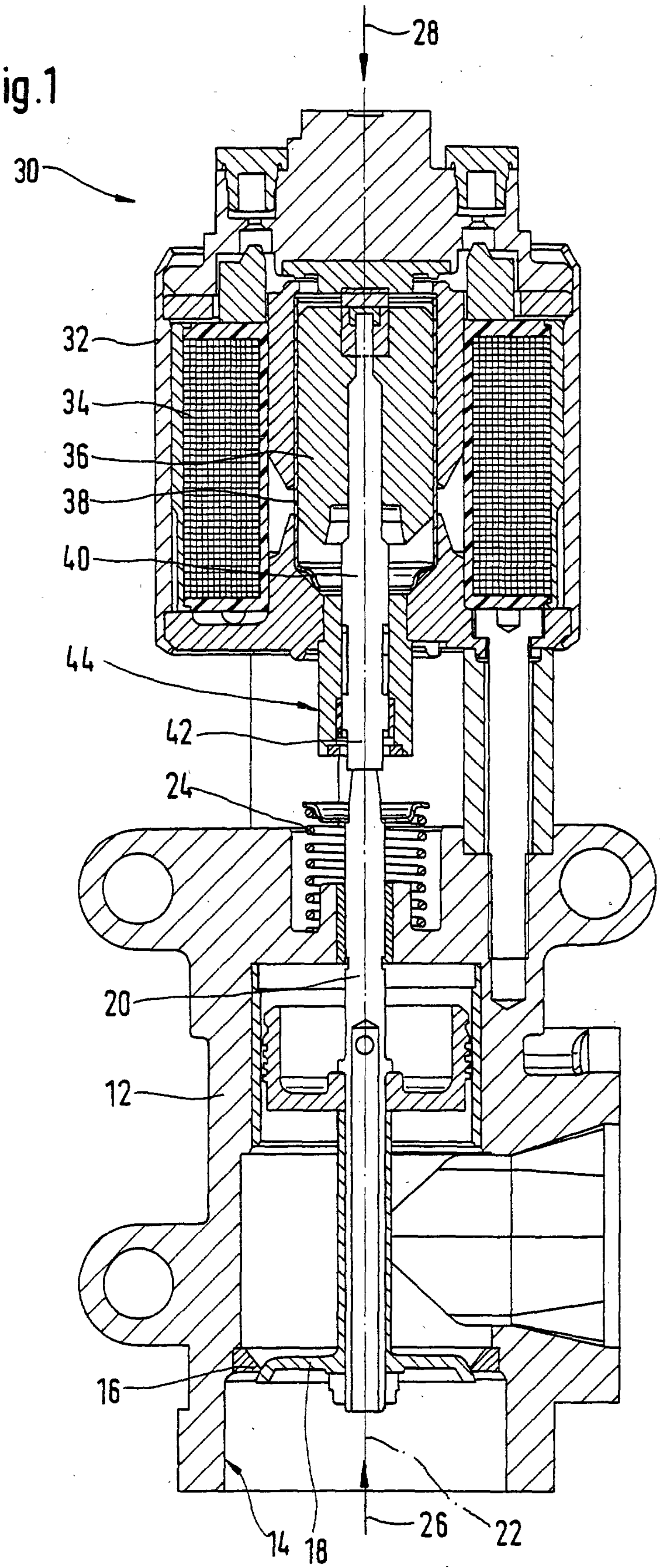


Fig.2

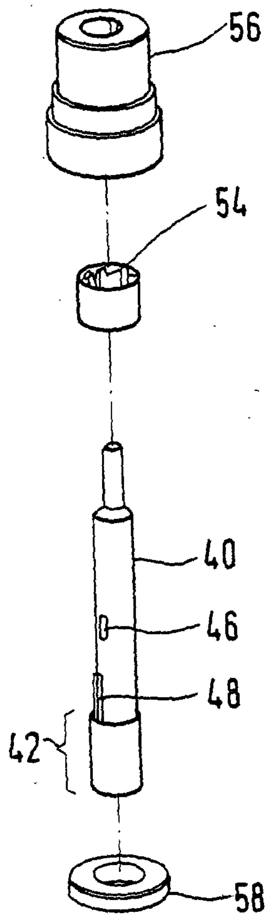


Fig.3

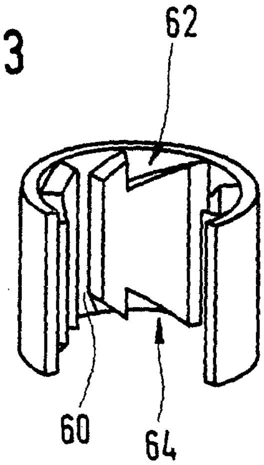


Fig.8

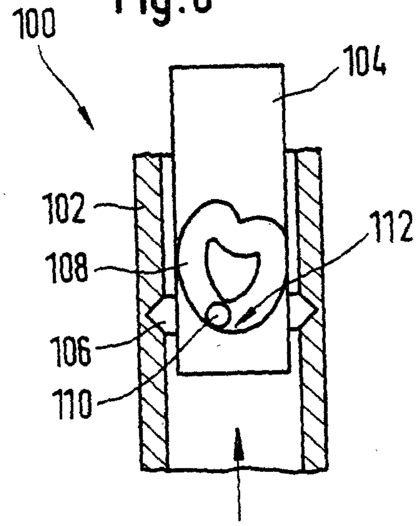


Fig.9

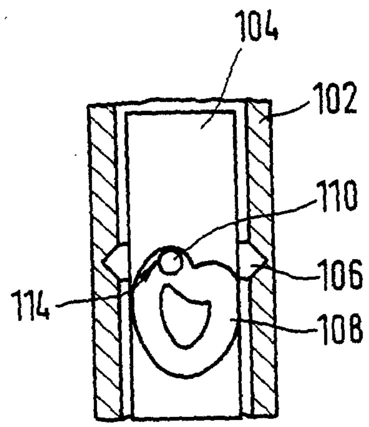
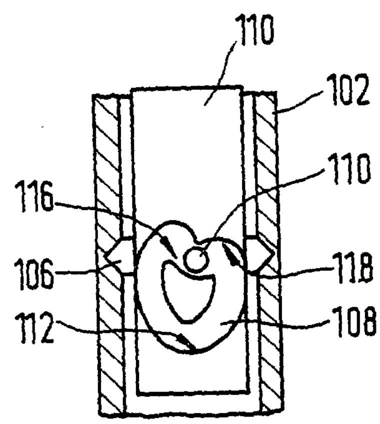


Fig.10



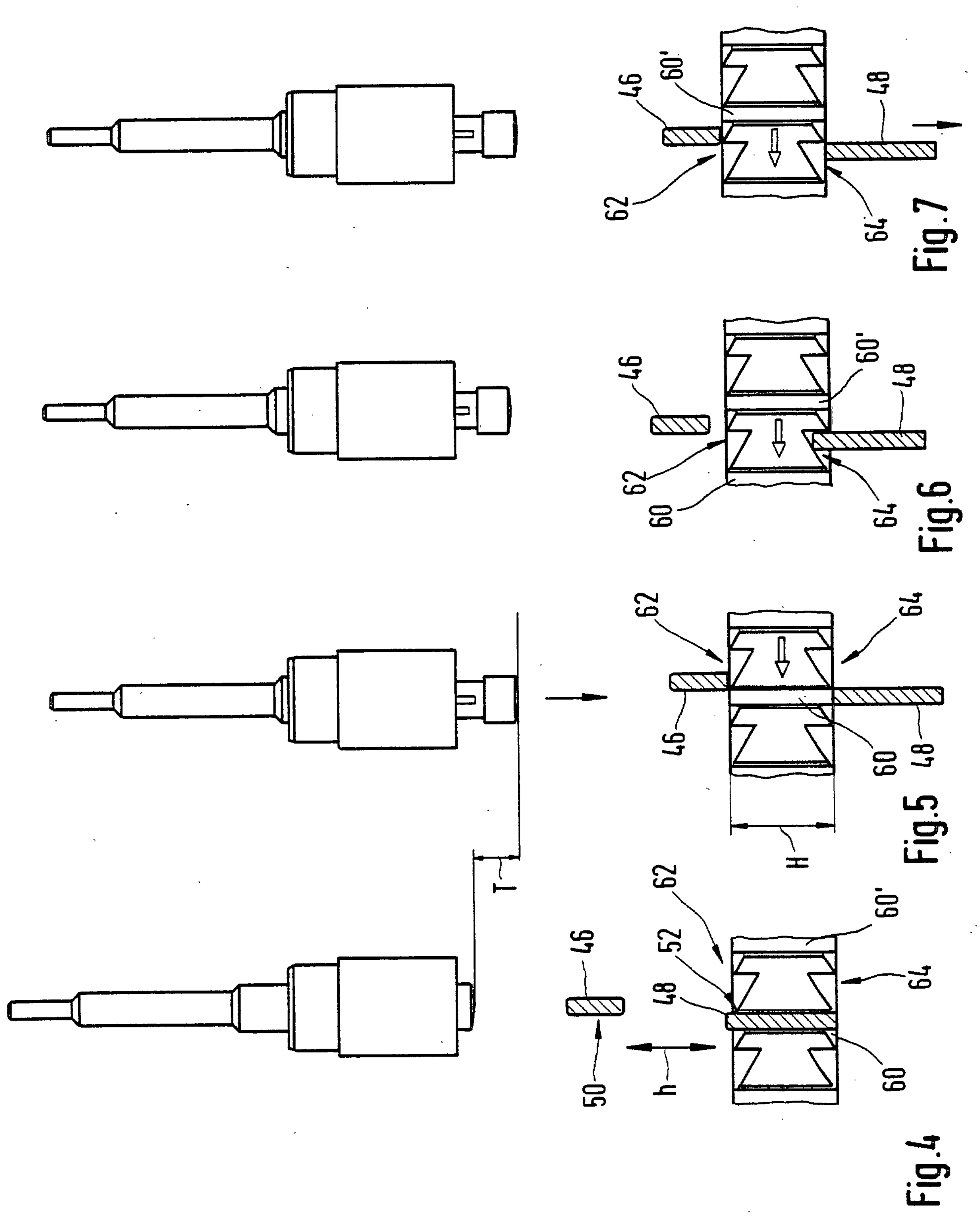


Fig.4
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EUROPEAN SEARCH REPORT

Application Number
EP 01 12 3282

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X A	DE 198 01 383 A (PIERBURG AG) 22 July 1999 (1999-07-22) * the whole document * ---	1,6 2-5,7	F02M25/07
D,A	DE 198 25 583 A (GUSTAV WAHLER GMBH & CO) 16 December 1999 (1999-12-16) * the whole document * ---	1	
A	EP 0 952 331 A (PIERBURG AG) 27 October 1999 (1999-10-27) * abstract; figures * -----		

TECHNICAL FIELDS SEARCHED (Int.Cl.7)
F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 October 2001	Döring, M

CATEGORY OF CITED DOCUMENTS

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29-10-2001

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