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(54) **A rocker arm mechanism for actuating valves in internal combustion engines**

Kipphebelmechanismus für die Ventilbetätigung in einer Brennkraftmaschine

Un culbuteur pour actionner les soupapes d'un moteur a combustion interne

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• **Mingozzi, Mario**  
**40010 S. Matteo della Decima, Bologna (IT)**

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(74) Representative: **Lanzoni, Luciano et al**  
**c/o BUGNION S.p.A.**  
**Via Goito, 18**  
**40126 Bologna (IT)**

(73) Proprietor: **VM MOTORI S.P.A.**  
**I-44042 Cento (Ferrara) (IT)**

(56) References cited:  
**DE-A- 2 438 227** **DE-A- 19 741 078**  
**GB-A- 1 051 107** **US-A- 2 926 645**  
**US-A- 3 082 755** **US-A- 5 190 000**

(72) Inventors:  
• **Feroli, Vilmo**  
**44042 Cento, Ferrara (IT)**

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## Description

**[0001]** The present invention relates to a rocker arm mechanism for actuating valves in internal combustion engines, in particular for diesel engines.

**[0002]** As is known, reciprocating internal combustion engines have a given number of valves which allow the cylinder to be supplied with fresh air or a fuel and air mixture, and allows the burnt gases to escape. The valves are actuated by suitable mechanisms which are kinematically connected to the drive shaft.

**[0003]** In particular, there are known valve actuating mechanisms in internal combustion engines, comprising a rocker arm which pivots on a support fixed above the head of the engine. One end of the rocker arm acts upon the engine valve stem, whilst the opposite end is connected to a camshaft by means of a connecting rod.

**[0004]** This type of rocker arm mechanism is described in document US-3 139 872.

**[0005]** In said document, the rocker arm is positioned on a support shaft, by means of a pin mounted on the shaft in such a way that it slides on and turns about it.

**[0006]** The pin is cylindrical in shape and is inserted in two circular openings in the side walls of the rocker arm to form a turning pair. There is a hole in the pin to allow the passage of the support shaft, with an axis at a right angle to the shared axis of the circular openings in the rocker arm, and the pin is held in position relative to the rocker arm by suitable spring means.

**[0007]** As a result of the connection to the pin alone, the rocker arm can turn, relative to the pin, in a plane containing the axis of the support shaft. Moreover, it can slide vertically on the support and turn in a plane at a right angle to the support together with the pin. The valve stem at one end, the connecting rod at the opposite end and a nut fixed on the shaft, against which the pin stops, hold the rocker arm in position. The actual motion of the rocker arm, caused by rotation of the camshaft, is an oscillation in the vertical plane about the pin. Therefore, the movement of the rocker arm causes the valve alternating motion.

**[0008]** The rocker arm mechanism of the type described is complex and bulky.

**[0009]** In particular, the structure of the pin - rocker arm connection makes the assembly very wide, meaning that otto engine spark plugs or diesel engine injectors cannot be mounted on the head of the engine, in advantageous positions.

**[0010]** The injector of a diesel engine is preferably fitted at the centre of the chamber, between the valves, and projects over the head of the engine in the same area as the rocker arms. The injector is normally inserted between the two mechanisms which move the intake valve and the exhaust valve.

**[0011]** Moreover, since the turning connection is not directly lubricated, the mechanism is prone to rapid wear and possible seizing.

**[0012]** Finally, the rocker arm described above is dif-

ficult to make, bulky and expensive, since its particular shape requires the use of machining for removing material or the construction of complex moulds.

**[0013]** Document US-2 926 645, which is considered the closest prior art, discloses a rocker arm assembly which comprises a pivotally mounted rocker arm and means for precluding transverse rotary movement about its pivotal mounting. Said pivotal mounting comprises a stud which is force fitted into a bore in the top of a cylinder head and a papered extremity which is passed through an elongated slot or aperture of the rocker arm. The rocker arm includes a hemispherical downwardly concaved portion, which surrounds the tapered extremity of the stud and which is adapted to contain a floating rocker ball, which is held in position by a self locking nut which holds the rocker arm in partial alignment, but which allows limited flexibility of play.

**[0014]** Document US-2 926 645 does not make provision of lubricating circuit which directly lubricates the rocker arm, the valve stem and the push rod.

**[0015]** The aim of the present invention is, therefore, to overcome the above-mentioned disadvantages.

**[0016]** The aim of the present invention is also to provide a rocker arm mechanism for actuating valves in internal combustion engines which is reliable and resistant to wear.

**[0017]** Another aim of the present invention is to provide a rocker arm mechanism for actuating valves in internal combustion engines which is simple and economical.

**[0018]** The technical task specified and the preset aims are substantially achieved by a rocker arm mechanism for actuating valves in internal combustion engines comprising the characteristics indicated in claim 1 and in the dependent claims.

**[0019]** The rocker arm mechanism for actuating valves in internal combustion engines according to the present invention is now described with reference to the accompanying drawings, which illustrate a preferred embodiment without limiting the scope of application, and in which:

- Figure 1 is a side view of a rocker mechanism for actuating valves in internal combustion engines, according to the present invention, mounted on the head of an engine;
- Figure 2 is a cross-section along line II - II illustrated in Figure 1;
- Figure 3 is a plan view of a first element of the mechanism illustrated in Figure 1;
- Figure 4 is a cross-section along line IV - IV illustrated in Figure 3;
- Figure 5 is a view from above of a second element of the mechanism illustrated in Figure 1;
- Figure 6 is a cross-section along line VI - VI illustrated in Figure 5;
- Figures 7 and 8 are a cross-section and a view from above of several details of an alternative embodi-

- ment of the mechanism illustrated in Figure 1; and
- Figure 9 is a cross-section of another embodiment of the mechanism illustrated in Figure 1.

**[0020]** With reference to the accompanying drawings, the numeral 1 denotes a rocker arm mechanism for actuating valves in internal combustion engines.

**[0021]** The rocker arm mechanism 1 comprises a support shaft 2 extending from the head 3 of an internal combustion engine, known and therefore not illustrated, at the position of an intake and/or exhaust valve 4 comprising a stem 4a. The shaft 2 may be made of hardened and tempered steel.

**[0022]** A support pin 5 is fitted on the shaft 2 in such a way that it slides and turns. As illustrated in the accompanying drawings, the pin 5 is semi-cylindrical, that is to say, it has the shape of one of the two portions obtained from the cross-section of a cylinder according to a plane parallel with the longitudinal axis of the cylinder and containing the axis, or passing close to the axis. The pin 5 may be made of sintered steel or aluminium.

**[0023]** The pin 5 has a first, flat base 6a, a second, flat base 6b opposite the first, a first, convex side surface 7a and a second, flat side surface 7b.

**[0024]** A through-hole 8 with straight axis is made in the semi-cylinder. The support shaft 2 is inserted in this hole. The hole 8 has a first open end 8a on the first, convex side surface 7a of the pin 5 and a second open end 8b on the second, flat side surface 7b of the pin 5.

**[0025]** The semi-cylinder is then mounted on the shaft 2 with the directrices at right angles to the axis of the shaft 2.

**[0026]** The mechanism 1 also comprises a rocker arm 9 mounted on the shaft 2 by connection with the pin 5.

**[0027]** The rocker arm 9 may be made by moulding, striking or smelting.

**[0028]** The rocker arm 9 has a seat 10 for the pin 5, the seat having a concave surface 11 connecting with the convex surface 7a of the pin 5, so that together with the pin 5 it forms a turning pair and allows relative rotation between the two elements in a vertical plane containing the axis of the support shaft 2.

**[0029]** In particular, at the seat 10 the cross-section of the rocker arm 9 is substantially U-shaped, open towards the free end of the support shaft 2. The side and bottom of the pin 5 are, therefore, connected to the internal surface of the rocker arm 9 and completely housed in it.

**[0030]** The shaft 2 passes through the rocker arm 9 at an opening 12 made in the rocker arm 9 and aligned with the hole 8 in the pin 5.

**[0031]** The opening 12 extends longitudinally on the rocker arm 9 in such a way that the support shaft 2 does not interfere with the rocker arm 9 and allows the latter to oscillate on the pin 5.

**[0032]** Therefore, as a result of a connection to the pin 5 only, the rocker arm 9 is free to turn in a vertical plane, moving relative to the pin 5, sliding along the sup-

port shaft 2 and turning about the longitudinal axis of the shaft 2, integral with the pin 5.

**[0033]** Alternatively, in an embodiment which is not illustrated, the pin 5 may be semi-spherical, that is to say, with the shape of one of the two portions obtained from the cross-section of a sphere according to a plane passing through the centre of the sphere or close to its centre.

**[0034]** In this case, the pin - rocker arm connection allows the rocker arm 9 to turn in any plane passing through the centre of the semi-spherical pin 5.

**[0035]** To prevent the pin 5 and rocker arm 9 from coming off the support shaft 2, the mechanism 1 comprises retaining means 13 which, in the present embodiment, simply consist of a washer 13a locked with a nut 13b screwed onto the free end of the shaft 2.

**[0036]** The second, flat side surface 7b of the pin 5 and the upper surface of the support shaft 2 where the washer 13a rests are at a height Z from the head 3 fixing surface. The height Z defines the precise system mounting position without the need for other adjustments.

**[0037]** The rocker arm 9 also has a first end 9a engaged with the valve 4 stem 4a and a second end 9b, opposite the first 9a, kinematically connected to a camshaft 14 by suitable means 15.

**[0038]** At the two ends 9a, 9b, the rocker arm rests on the valve 4 stem and the means for connection 15 to the camshaft 14 and, through the pin 5, on the contact washer 13a.

**[0039]** Moreover, to prevent rotation about the shaft 2, the rocker arm 9 is fitted with a guide 16 on the first end 9a, in which the valve 4 stem 4a engages, and with a seat 17 for the connecting means 15 on the second end 9b.

**[0040]** It should be noticed that by engaging with the end of the stem 4a, the guide 16 holds the rocker arm 9 in the correct operating position without the need for any other devices to prevent rotation about the shaft 2. Any side thrust on the valve 4 is limited and does not increase wear on the stem 4a and the valve guide 4b.

**[0041]** In the embodiment illustrated, the connecting means 15 comprise a connecting rod 18 with a first end 18a connected to the seat 17, on the second end 9b of the rocker arm 9, and a second end 18b in contact with the camshaft 14, in accordance with the known rod and rocker arm distribution system.

**[0042]** Moreover, the second end 18b of the rod 18 is fitted with a hydraulic tappet 19 for automatic compensation of valve clearance.

**[0043]** In an embodiment which is not illustrated there is no rod, since the camshaft 14 is close to the rocker arm 9, therefore, the hydraulic tappet 19 is mounted directly on the rocker arm 9, normally on the second end 9b.

**[0044]** Advantageously, the mechanism 1 has a channel 20 with at least one open end 21 at the pin 5 seat 10 in the rocker arm 9. The channel 20 is in communication with the engine lubrication circuit and guarantees continuous lubrication of the turning pair.

[0045] Advantageously, the channel 20 has a first portion 20a made in the support shaft 2 along the longitudinal axis. A first end 22a of the first portion 20a allows fluid communication with the engine lubrication circuit, whilst at least one second end 22b opens at the pin 5.

[0046] The channel 20 preferably has at least a second portion 20b, connecting the first portion 20a to the surface of the turning connection through the pin 5.

[0047] As illustrated in the accompanying drawings, the first portion 20a of the channel 20 branches at the pin 5 to form a ring-shaped passage on the entire edge 22b, from which two branches 20b in the pin 5 start. In this way, the contact zone between the pin 5 and the rocker arm 9 can be lubricated more efficiently.

[0048] Advantageously, the channel 20 also has a third portion 20c, made in the rocker arm 9, between the pin 5 seat 10 and the second end 9b of the rocker arm 9, which carries the oil as far as the hydraulic tappet 19.

[0049] In the embodiment illustrated, which comprises the connecting rod 18, the channel 20 has a fourth portion 20d which passes through the rod 18 as far as the hydraulic tappet 19, located at the second end 18b of the rod 18.

[0050] The latter portion, therefore, allows the use of a single circuit to supply the hydraulic tappet and to lubricate the turning pair.

[0051] Figures 7 and 8 illustrate an alternative embodiment of the rocker arm 9, in which the third portion 20c of the lubrication channel is obtained by folding a portion 9d of the sheet metal which forms the rocker arm, so that a cavity is formed.

[0052] The sheet metal has grooves 20e which were obtained previously during the moulding stage. The grooves 20e, in the sheet metal which is folded over itself, form the third portion 20c of the lubricating channel.

[0053] Figure 9 illustrates an alternative embodiment of the third portion 20c of the lubrication channel. In this case, the folded portion of sheet metal 9d extends downwards in the contact zone between the pin 5 and the rocker arm 9. There is a hole and a recess 20f for the passage of the oil. The recess allows the lubricant to pass from the pin 5 to the rocker arm 9 even during rocker arm 9 oscillations.

[0054] In the zone of the first end 9a engaged with the valve 4 stem 4a, the rocker arm 9 also has a hole 9c which allows improved lubrication in the contact zone between the stem 4a and the rocker arm 9. It should be noticed that the end 9a is spoon-shaped, collecting the lubricant and distributing it, through the hole 9c, to the contact zone between the stem 4a and the rocker arm 9.

[0055] The invention has important advantages. Firstly, the rocker arm mechanism disclosed has a limited width and, therefore, allows easy positioning of the injector on the head of a diesel engine, for example between two adjacent rocker arms which respectively actuate an intake valve and an exhaust valve.

[0056] Moreover, the mechanism disclosed is reliable and relatively silent, since the pin - rocker arm connection is continuously lubricated during operation.

In addition, the mechanism disclosed allows automatic compensation of valve clearance by means of hydraulic tappets supplied with the pin - rocker arm connection lubricating oil, without the need for auxiliary systems to supply the oil to the tappet.

[0057] The rocker arm mechanism made in accordance with the present invention is extremely simple to maintain, because all of the components are fully interchangeable. No wear is caused on the head 3, since the connection is limited to contact with the support shaft 2.

[0058] Finally, the rocker arm mechanism disclosed is easy to make and very economical, because the rocker arm body can be made by moulding and/or striking and further machining on machine tools is not required.

## Claims

1. A rocker arm mechanism for actuating valves in internal combustion engines, comprising:

a support shaft (2) extending from the head (3) of an engine;

a pin (5) mounted in such a way that it slides on and turns about the shaft (2)

at least one valve (4), located in the head (3) and having a stem (4a);

a rocker arm (9) connected to the pin (5) and having a first end (9a) connected to the stem (4a) and a second end (9b); the rocker arm (9) also having a seat (10) for the pin (5) between the first (9a) and the second (9b) ends so that, together with the pin (5), it forms a turning pair; at the seat (10) the cross-section of the rocker arm (9) being substantially U-shaped, forming a concave surface (11) facing the free end of the support shaft (2) and containing the pin (5);

a camshaft (14) for actuating the valve (4);

means (15) for kinematically connecting the camshaft (14) to the second end (9b) of the rocker arm (9);

means (13) for connecting the pin (5) to the support shaft (2);

the rocker arm mechanism being **characterised in that** it comprises at least one channel (20) for the passage of a lubricant, the channel having one open end (21) at the seat (10) for the pin (5); the channel (20) having a first portion (20a) made in the support shaft (2), at least one second portion (20b) made in the pin (5) and in fluid communication with the first portion (20a), a third portion (20c) made in the rocker arm (9), between the seat (10) for the pin (5) and the second end (9b) of the rocker arm (9).

2. The rocker arm mechanism according to claim 1, **characterised in that** the first end (9a) comprises

a guide (16) which engages with the end of the stem (4a) to hold the rocker arm (9) in the correct position relative to the valve (4).

3. The rocker arm mechanism according to claim 1 or 2, **characterised in that** the means (15) for kinematically connecting the camshaft (14) to the rocker arm (9) comprise a hydraulic tappet (19) mounted on the second end (9b) of the rocker arm (9) and in contact with the camshaft (14); the hydraulic tappet (19) being in fluid communication with the third portion (20c) of the channel (20).
4. The rocker arm mechanism according to claim 3, **characterised in that** the means (15) for kinematically connecting the camshaft (14) to the rocker arm (9) comprise a connecting rod (18) with a first end (18a) attached to the second end (9b) of the rocker arm (9) and a second end (18b) in contact with the camshaft (14); a hydraulic tappet (19) for automatic compensation of valve clearance being mounted on the second end (18b) of the rod (18).
5. The rocker arm mechanism according to claim 4, **characterised in that** the channel (20) has a fourth portion (20d) made in the connecting rod (18) and extending between the third portion (20c) and the hydraulic tappet (19), carrying the lubricant to the hydraulic tappet (19).
6. The rocker arm mechanism according to any of the foregoing claims, **characterised in that** the shape of the pin (5) is substantially semi-spherical.
7. The rocker arm mechanism according to any of claims 1-5, **characterised in that** the pin (5) is substantially semi-cylindrical and has directrices at right angles to the longitudinal axis of the support shaft (2).

#### Patentansprüche

1. Hebelmechanismus für die Ventilbetätigung in Brennkraftmaschinen, enthaltend:
  - eine Trägerwelle (2), die sich von dem Kopf (3) eines Motors aus erstreckt;
  - einen auf solche Weise montierten Zapfen (5), dass dieser an der Welle (2) gleitet und sich um die Welle dreht;
  - wenigstens ein Ventil (4), angeordnet in dem Kopf (3) und einen Schaft (4a) aufweisend;
  - einen an den Zapfen (5) angeschlossenen Kipphebel (9) mit einem ersten Ende (9a), das an den Schaft (4a) angeschlossen ist, und einem zweiten Ende (9b); wobei der Kipphebel (9) ebenfalls einen Sitz (10) für den Zapfen (5)

zwischen dem ersten (9a) und dem zweiten (9b) Ende aufweist, so dass er zusammen mit dem Kipphebel (5) ein Drehpaar bildet;

- wobei an dem Sitz (10) der Querschnitt des Kipphebels (9) im wesentlichen U-förmig ist, eine dem freien Ende der Trägerwelle (2) zugewandte konkave Oberfläche (11) bildet und den Zapfen (5) enthält;
- eine Nockenwelle (14) zur Betätigung des Ventils (4);
- Mittel (15) für die kinematische Verbindung der Nockenwelle (14) mit dem zweiten Ende (9b) des Kipphebels (9); Mittel (13) zum Anschluss des Zapfens (5) an die Trägerwelle (2);
- wobei der Kipphebelmechanismus **dadurch gekennzeichnet ist, dass** er wenigstens einen Kanal (20) für den Durchlauf eines Schmiermittels enthält, wobei der Kanal (20) an dem Sitz (10) für den Zapfen (5) ein offenes Ende (21) aufweist; wobei der Kanal (20) einen ersten Abschnitt (20a) aufweist, der in die Trägerwelle (2) eingearbeitet ist, und wenigstens einen zweiten Abschnitt (20b), eingearbeitet in den Zapfen (5) und in Flüssigkeitsverbindung mit dem ersten Abschnitt (20a) stehend, sowie einen dritten Abschnitt (20c), der in den Kipphebel (9) eingearbeitet ist, und zwar zwischen dem Sitz (10) für den Zapfen (5) und dem zweiten Ende (9b) des Kipphebels (9).
2. Kipphebelmechanismus nach Patentanspruch 1, **dadurch gekennzeichnet, dass** das erste Ende (9a) eine Führung (16) enthält, die sich mit dem Ende des Schaftes (4a) verbindet, um den Kipphebel (9) in der korrekten Position im Verhältnis zu dem Ventil (4) zu halten.
3. Kipphebelmechanismus nach Patentanspruch 1 oder 2, **dadurch gekennzeichnet, dass** die Mittel (15) für die kinematische Verbindung der Nockenwelle (14) mit dem Kipphebel (9) einen Hydraulikstößel (19) enthalten, montiert an dem zweiten Ende (9b) des Kipphebels (9) und im Kontakt mit der Nockenwelle (14); wobei der Hydraulikstößel (19) in Flüssigkeitsverbindung mit dem dritten Abschnitt (20c) des Kanals (20) steht.
4. Kipphebelmechanismus nach Patentanspruch 3, **dadurch gekennzeichnet, dass** die Mittel (15) für die kinematische Verbindung der Nockenwelle (14) mit dem Kipphebel (9) eine Verbindungsstange (18) enthalten, und zwar mit einem ersten Ende (18a), das an das zweite Ende (9b) des Kipphebels (9) angeschlossen ist, und einem zweiten Ende (18b) im Kontakt mit der Nockenwelle (14); wobei ein Hydraulikstößel (19) für den automatischen Ausgleich des Ventilspiels an dem zweiten Ende (18b) der Stange (18) montiert ist.

5. Kipphebelmechanismus nach Patentanspruch 4, **dadurch gekennzeichnet, dass** der Kanal (20) einen vierten Abschnitt (20d) hat, eingearbeitet in die Verbindungsstange (18) und sich zwischen dem dritten Abschnitt (20c) und dem Hydraulikstößel (19) erstreckend und das Schmiermittel an den Hydraulikstößel (19) leitend. 5
6. Kipphebelmechanismus nach einem beliebigen der vorstehenden Patentansprüche, **dadurch gekennzeichnet, dass** der Zapfen (5) im wesentlichen halbkugelförmig ist. 10
7. Kipphebelmechanismus nach einem beliebigen der Patentansprüche von 1 bis 5, **dadurch gekennzeichnet, dass** der Zapfen (5) im wesentlichen von einer halbzyklindrischen Form ist und Leitlinien in rechten Winkeln zu der Längsachse der Trägerwelle (2) aufweist. 15

### Revendications

1. Un mécanisme à culbuteur pour actionner les soupapes d'un moteur à combustion interne, comprenant : 25

un arbre de support (2) s'étendant à partir de la tête (3) d'un moteur ;

un pivot (5) monté de manière à coulisser sur l'arbre (2) et à tourner autour de ce dernier ; 30

au moins une soupape (4), située dans la tête (3) et ayant une tige (4a) ;

un culbuteur (9) associé au pivot (5) et ayant une première extrémité (9a) associée à la tige (4a) et une seconde extrémité (9b) ; le culbuteur (9) présentant également un logement (10) pour le pivot (5) entre la première (9a) et la seconde (9b) extrémités de manière à former, avec ledit pivot (5), un couple de rotation ; 35

la section transversale du culbuteur (9) ayant essentiellement, au niveau du logement (10), une forme en « U » définissant une surface concave (11) orientée vers l'extrémité libre de l'arbre de support (2) et contenant le pivot (5) ; 40

un arbre à cames (14) pour actionner la soupape (4) ;

des moyens (15) pour relier cinématiquement l'arbre à cames (14) à la seconde extrémité (9b) du culbuteur (9) ; 45

des moyens (13) pour associer le pivot (5) à l'arbre de support (2) ;

le mécanisme à culbuteur étant **caractérisé en ce qu'il** comprend au moins un canal (20) pour le passage d'un lubrifiant, le canal ayant une extrémité ouverte (21) au niveau du logement (10) du pivot (5) ; le canal (20) ayant une première portion (20a) réalisée dans l'arbre de 55

support (2), au moins une deuxième portion (20b) réalisée dans le pivot (5) et en communication de fluide avec la première portion (20a), et une troisième portion (20c) réalisée dans le culbuteur (9) entre le logement (10) du pivot (5) et la seconde extrémité (9b) du culbuteur (9).

2. Le mécanisme à culbuteur selon la revendication 1, **caractérisé en ce que** la première extrémité (9a) comprend un guide (16) qui vient en prise avec l'extrémité de la tige (4a) pour maintenir le culbuteur (9) dans la position appropriée par rapport à la soupape (4).

3. Le mécanisme à culbuteur selon la revendication 1 ou 2, **caractérisé en ce que** les moyens (15) pour relier cinématiquement l'arbre à cames (14) au culbuteur (9) comprennent un poussoir hydraulique (19) monté sur la seconde extrémité (9b) du culbuteur (9) et au contact de l'arbre à cames (14) ; le poussoir hydraulique (19) étant en communication de fluide avec la troisième portion (20c) du canal (20). 20

4. Le mécanisme à culbuteur selon la revendication 3, **caractérisé en ce que** les moyens (15) pour relier cinématiquement l'arbre à cames (14) au culbuteur (9) comprennent une tige de liaison (18) ayant une première extrémité (18a) associée à la seconde extrémité (9b) du culbuteur (9) et une seconde extrémité (18b) au contact de l'arbre à cames (14) ; un poussoir hydraulique (19) pour la compensation automatique du jeu à la soupape étant monté sur la seconde extrémité (18b) de la tige (18). 25

5. Le mécanisme à culbuteur selon la revendication 4, **caractérisé en ce que** le canal (20) présente une quatrième portion (20d) réalisée dans la tige de liaison (18) et s'étendant entre la troisième portion (20c) et le poussoir hydraulique (19) afin d'amener le lubrifiant au poussoir hydraulique (19) lui-même. 30

6. Le mécanisme à culbuteur selon l'une quelconque des revendications précédentes, **caractérisé en ce que** le pivot (5) a une forme essentiellement semi-sphérique. 35

7. Le mécanisme à culbuteur selon l'une quelconque des revendications de 1 à 5, **caractérisé en ce que** le pivot (5) est essentiellement semi-cylindrique et présente des directrices à angle droit avec l'axe longitudinal de l'arbre de support (2). 40

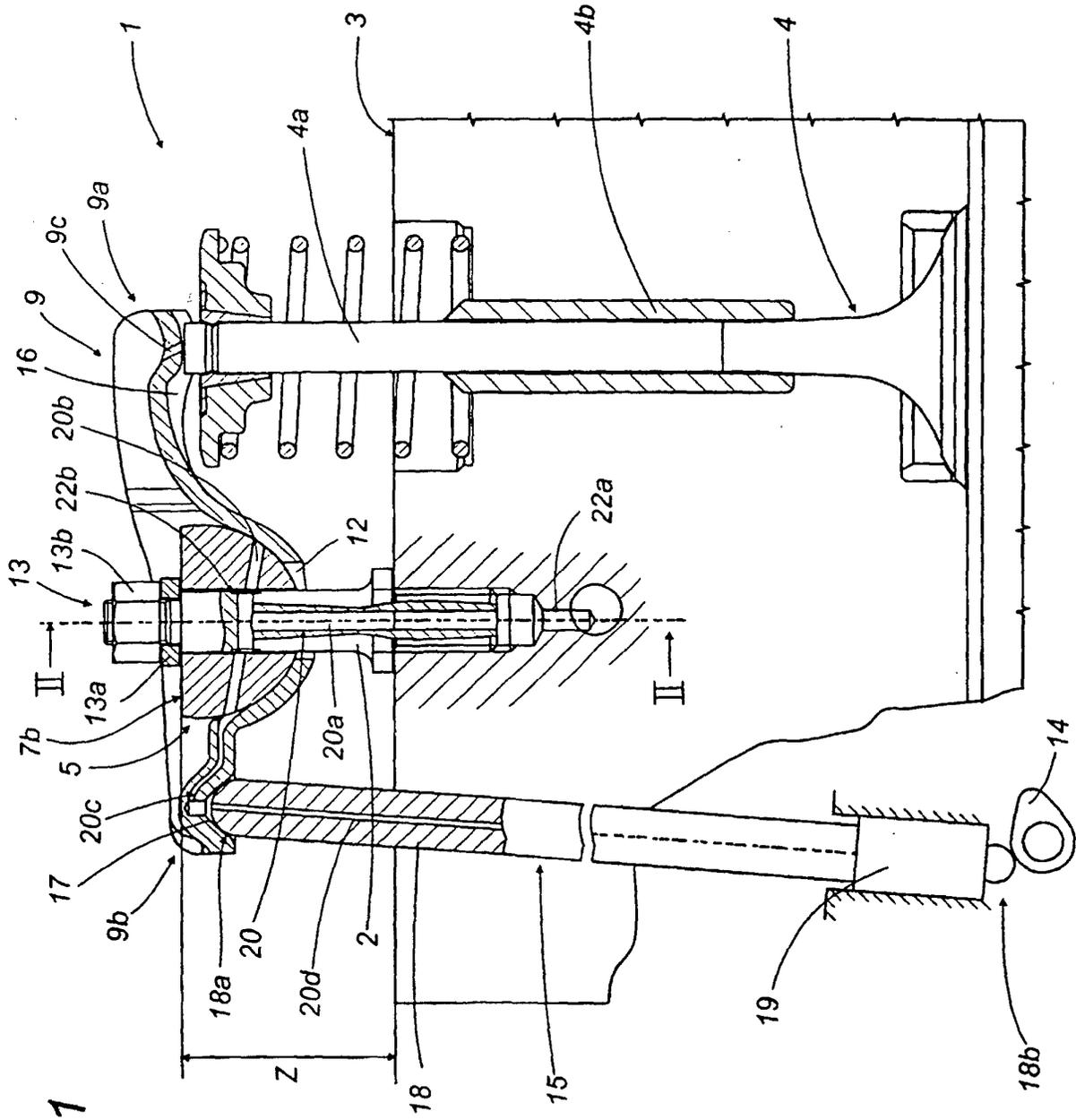


FIG. 1

FIG.2

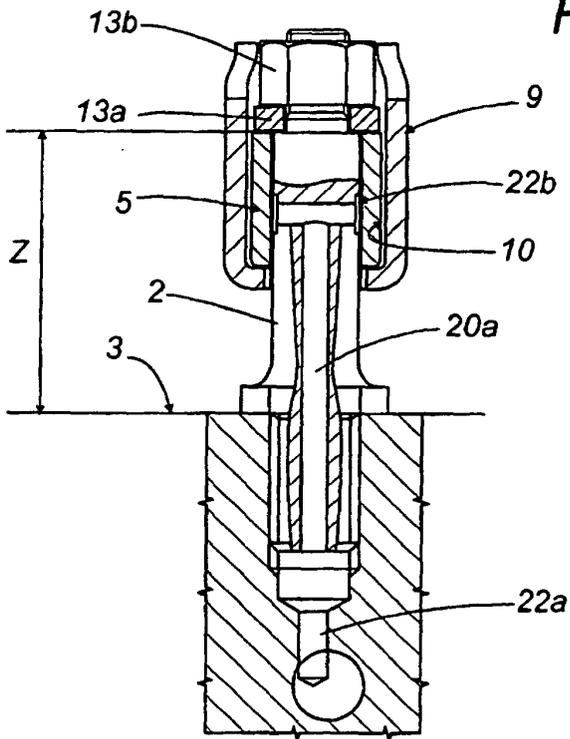


FIG.4

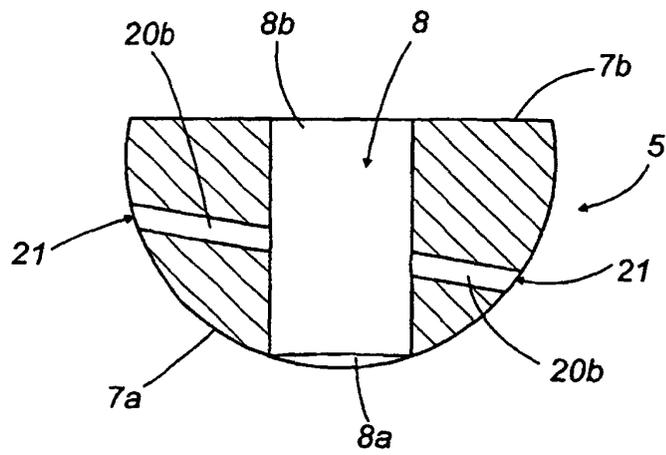


FIG.3

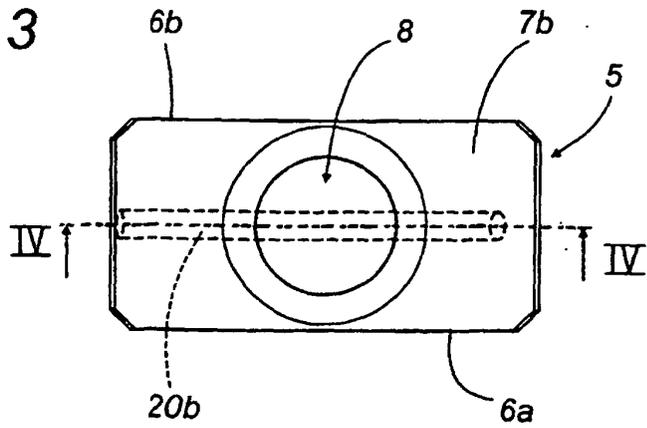


FIG.6

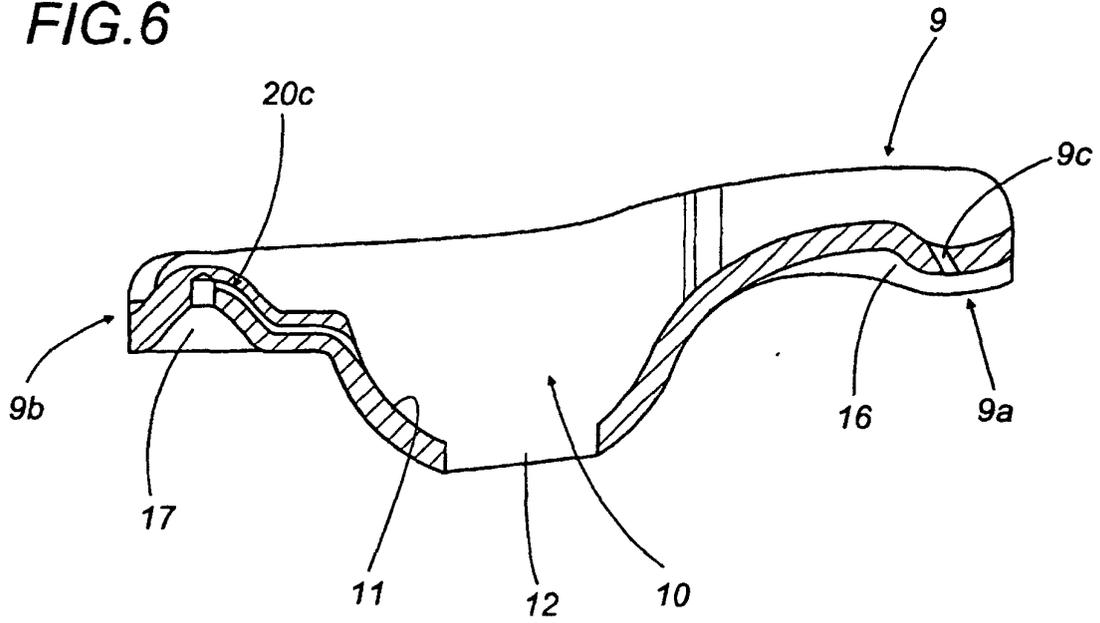


FIG.5

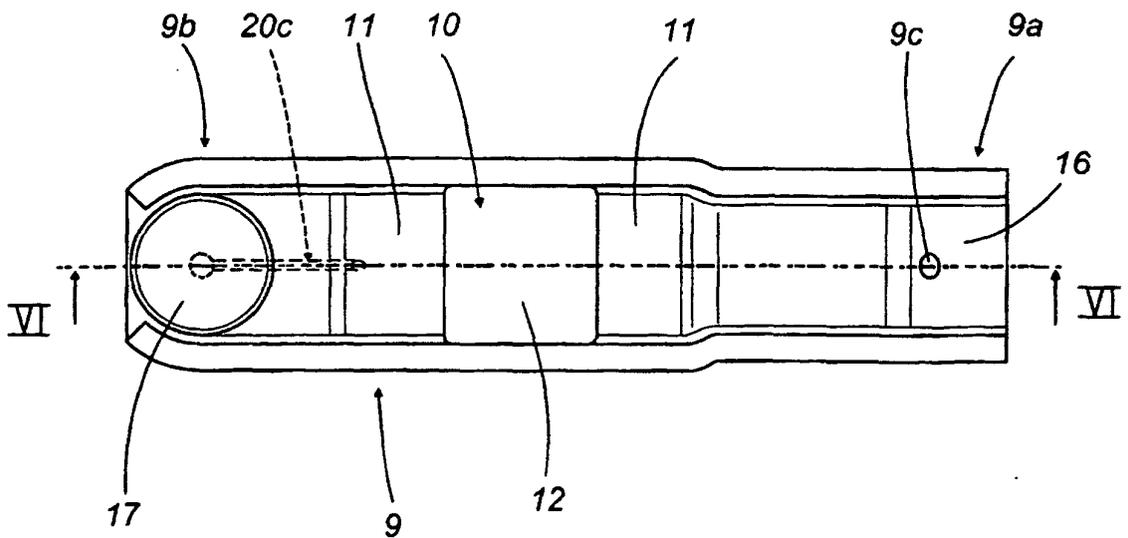


FIG. 7

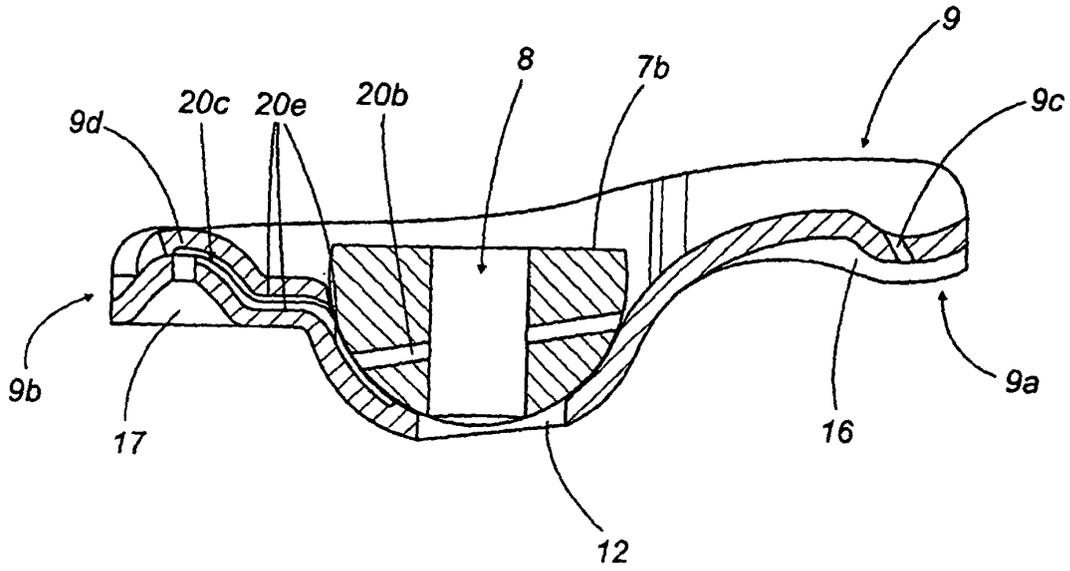


FIG. 8

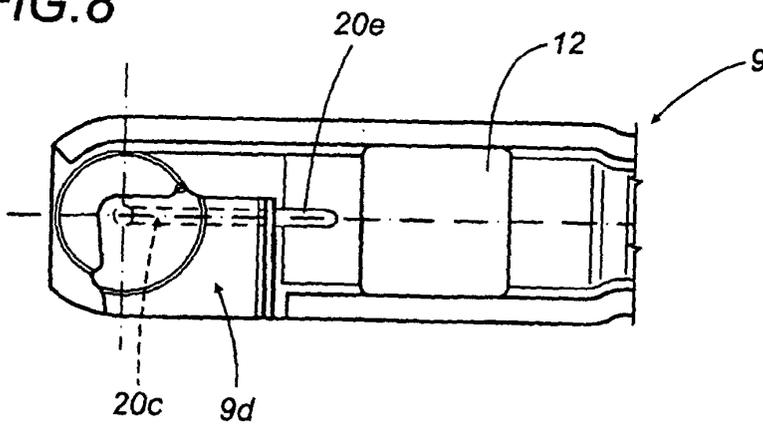


FIG. 9

