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(54) **PUMP FOR A FUEL INJECTION SYSTEM OF AN INTERNAL COMBUSTION ENGINE WITH AN IMPROVED DELIVERY VALVE**

PUMPE FÜR EIN KRAFTSTOFFEINSPRITZSYSTEM EINES VERBRENNUNGSMOTORS MIT EINEM VERBESSERTEN DRUCKVENTIL

POMPE POUR UN SYSTÈME D'INJECTION DE CARBURANT D'UN MOTEUR À COMBUSTION INTERNE AVEC UNE SOUPAPE DE REFOULEMENT AMÉLIORÉE

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(56) References cited:
EP-A- 1 813 845
DE-A1-102004 027 825
DE-A1-102005 061 886
GB-A- 513 349
JP-A- 2005 024 022

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Description

[0001] The present invention relates to a pump comprising an improved delivery valve, and preferably to a high-pressure pump for a fuel injection system of an internal combustion engine.

[0002] A high-pressure pump is generally used in a fuel injection system which comprises a low-pressure branch, a pre-feed pump which draws the fuel from a tank and conveys it to a high-pressure pump via the low-pressure branch and a high-pressure branch which connects a delivery of the high-pressure pump to a group of injectors via an accumulator, commonly called a "common rail".

[0003] The high-pressure pump comprises a plurality of pumping cylinders operated by a driving shaft via a lobed body or via a cam. The pumping cylinders slide in a reciprocating manner inside respective compression chambers, each of which is connected in flow terms to an intake valve and a delivery or high-pressure valve. Generally the high-pressure or delivery valve is a non-return valve.

[0004] A high-pressure valve comprises a ball shut-off member biased by means of a coil spring against a conical seat. Upstream the conical seat is connected in flow to the compression chamber and downstream the high-pressure valve is connected in flow to the common rail.

[0005] The fuel flow which passes through the high-pressure valve exerts a complex hydrodynamic action on the shut-off member which results in wear and a delay in the dynamic response.

[0006] In particular, owing to both the high operating speeds of the pump and the high flow rates, the hydraulic forces acting on the shut-off member are such as to generate a torque which causes the shut-off member to rotate about the axis of the spring and thus produces both friction of the latter against the spring and a delay in the closing action.

[0007] From the document GB-C-513 349 a pump for a fuel injection system is known, comprising a seat connected in flow terms to the delivery of a compression chamber and having an axis, an outlet duct for connecting the said seat to a plurality of Injectors, a shut-off member housed inside the said seat, a spring for biasing the said shut-off member against a first contact surface of the said seat in a closed position. Said spring being arranged downstream of the said shut-off member, wherein a first through-opening in the axial direction, arranged downstream of said shut-off member, is present inside the said seat and wherein it comprises fuel flow deviation means arranged inside the said seat upstream of the said outlet duct and configured so that the speed of the fuel flow is greater between the said shut-off member and the said opening than upstream of the said shut-off member. There is a first hydraulic resistance downstream of the shut-off member which is configured in the shut-off member and a second hydraulic resistance downstream of the shut-off member. During the initial opening phase of the shut-off member only the first hydraulic resistance is open and during the opening movement of the shutt-off member the second hydraulic resistance is open. Therefore only during the initial opening phase of the shut-off member an additional opening force on the shut-off member is created.

[0008] The object of the present invention is to provide a feed pump for a fuel injection circuit which does not have the abovementioned drawbacks.

[0009] According to the invention, this object is achieved by a pump for a fuel injection system of an internal combustion engine, comprising a seat connected in flow terms to the delivery of a compression chamber, an outlet duct for connecting the seat to a plurality of injectors, a shut-off member housed inside the seat, a spring for biasing the shut-off member against a first contact surface of the seat in a closed position, the seat being provided with a first through-opening in the axial direction, arranged downstream of the shut-off member, and fuel flow deviation means being provided upstream of the outlet duct and configured so that the speed of the fuel flow is greater between the shut-off member and the opening than upstream of the shut-off member.

[0010] The fuel flow deviation means are configured so as to direct the flow towards the opening so that the speed of the fuel increases immediately downstream of the shut-off member and a negative pressure is therefore created. This negative pressure pushes the shut-off member against the spring and reduces rotation of the shut-off member. Moreover, when the fluid tends to change direction during the intake phase of the pumping member, the pressure is localized along the axis of the spring and is applied effectively to the shut-off member so as to favour a closing action.

[0011] Further details, characteristic features and advantages of the invention will emerge more clearly from the following, description of a non-limiting example of embodiment provided with reference to the accompanying drawings in which:

- Figure 1 is a partially cross-sectioned view of the head of a feed pump according to the present invention; and
- Figure 2 is a prospective view of a component according to Figure 1.

[0012] In Figure 1, 1 denotes generically the head of a reciprocating fuel feed pump. The head defines a compression chamber 2 housing a pumping member 3 and a delivery valve 4 connected to the delivery of the chamber 2. The delivery valve 4 is a non-return valve.

[0013] The compression chamber 2 has an axis A and is closed axially by a threaded member 5 screwed into the head 1. The valve 4 is connected to the delivery of the compression chamber 2 via a duct 6 having an axis B perpendicular to the axis A.

[0014] The duct 6 emerges inside a seat 7 of the valve

4 defined by a cylindrical wall 8 coaxial with the duct 6 and by a frustoconical contact surface 9 axially arranged between the duct 6 and the cylindrical wall 8. The seat 7 is also connected to a duct 10 having an axis C parallel to the axis A and connected to the injectors preferably via a common rail, both not shown.

[0015] According to a preferred embodiment of the present invention, the valve 4 comprises a ball shut-off member 11 designed to cooperate selectively with the contact surface 9; a coil spring 12 for keeping the shut-off member 11 pressed against the contact surface 9 in a closed position; and a closing member 13 for pre-stressing the spring 12.

[0016] The closing member 13 is connected rigidly to the head 1 preferably by means of a threaded connection and comprises, for example in the form of a single body, a closing head-piece 14 screwed into the head 1 in a fluid-type manner and a cylindrical body 15 housed inside the seat 7.

[0017] The cylindrical body 5 defines preferably a radial through-hole 16 coaxial during use with the axis C and an axial cavity 17 communicating with the hole 16 via an opening 18 and open towards the contact wall 9. The axial cavity 17 houses the spring 12 and is cylindrical with an internal diameter smaller than that of the shut-off member 11.

[0018] The opening 18 is situated on the opposite side to the shut-off member 11 relative to the spring 12 and is situated in an axial position lying between the axis C and the cavity 17.

[0019] Towards the contact wall 9, the cylindrical body 15 comprises an annular end portion 19 which defines a flaring 20 and at least one radial through-goove 21.

[0020] The spring 12 is housed inside the axial cavity 17 so as to be coaxial with the axis B and the shut-off member 11 makes contact with the contact surface 9 when the valve 4 is closed. The valve 4 opens when the shut-off member 11 separates from the contact surface 9 and is able to reach the fully open condition when the shut-off member 11 makes contact with the flaring 20.

[0021] Moreover, according to the present invention, the cylindrical body 15 is mounted with radial play of its diameter inside the seat 7 so that the hydraulic resistance defined by the aperture 22 between the cylindrical bod 15 and the cylindrical wall 8 is greater than that defined by the groove 21, the coils of the spring 12, the opening 18 and the hole 16.

[0022] Moreover, the diameter of the duct 6 and the dimensions of the groove 21 are such as to ensure that the speed of the fuel inside the cavity 17 is greater than that inside the duct 6.

[0023] During use, the flow of fuel pumped by the member 3 opens the shut-off member 11 when the pressure upstream of the valve 4 is greater than the sum of the pressure downstream of the shut-off member and the equivalent, in terms of pressure, of the pre-stressing force of the spring 12.

[0024] When the valve 4 is open, in the fully open condition, the shut-off member 11 makes contact against the flaring 20 and most of the flow is directed along a path which leads from the groove 21 to the hole 16 through the coils of the spring 12 and the opening 18 since the hydraulic resistance of this path is less than that defined by the aperture 22 between the annular end portion 19 and the duct 10.

[0025] In this way the fuel flow generates a negative pressure inside the cavity 17 and the shut-off member 11 is pressed with an additional force against the flaring 20. Consequently, the frictional force increases and the rotational movement of the shut-off member decreases when the valve 4 is open.

[0026] When the pumping member 3 retracts in order to start the intake phase, the sum of the pressure downstream of the valve 4 and the equivalent pressure of the spring 12 is greater than the pressure inside the compression chamber 2. The response time of the shut-off member 11 decreases and the pressure signal present inside the duct 10 is transmitted effectively to the shut-off member 11 via the through-hole 16 and the opening 18.

[0027] From that described with reference to the accompanying figures the operating principle and advantages of the pump according to the present invention clearly emerge.

[0028] It has been established that the reduction in the rotational movement of the shut-off member 11 during the opening phase of valve 4 reduces the delay in the dynamic response of the said valve 4 and also the wear of the shut-off member 11.

[0029] In fact, in particular operating conditions, the speed of rotation of the shut-off member 11 about the axis B is so high that the shut-off member continues to rotate even when the pumping member 3 reverses its movement and starts the intake phase, preventing closure of the valve also - in the worst of cases - for the entire duration of the intake phase.

[0030] The reduction in the rotational movement of the shut-off member 11 is obtained by means of a particular deviation of the fuel flow inside the cavity 17. This deviation of the flow requires machining of the closing member 13 which is not expensive and does not affect other components and the assembly procedure. In this way, the general configuration of the pump remains unvaried and the costs associated with modification of the apparatus and the assembly cycles are avoided.

[0031] Finally, it is clear that the fuel pump described and illustrated here may be subject to modifications and variations without thereby departing from the protective scope of the present invention, as defined in the accompanying claims.

[0032] In particular, the number of grooves 21 may be more than one, for example up to five, so as to ensure that the speed of the fuel flow inside the cavity 17 is greater than that inside the duct 6.

[0033] The aperture 22 may also be completely closed in the case where the part 15 engages precisely with the

cylindrical surface 8 of the seat 7. In this case, the hydraulic resistance is practically infinite and the entire flow of fuel which passes through the valve 4 flows through the coils of the spring 12 and the opening 18.

Claims

1. Pump for a fuel injection system of an internal combustion engine, comprising a seat (7) connected in flow terms to the delivery of a compression chamber (2) and having an axis (B), an outlet duct (10) for connecting the said seat (7) to a plurality of injectors, a shut-off member (11) housed inside the said seat (7), a spring (12) for biasing the said shut-off member (11) against a first contact surface (9) of the said seat (7) in a closed position, said spring (12) being arranged downstream of the said shut-off member (11), wherein a first through-opening (18) in the axial direction, arranged downstream of said shut-off member (11), is present inside the said seat (7) and wherein it comprises fuel flow deviation means (21, 22) arranged inside the said seat (7) upstream of the said outlet duct (10) and configured so that the speed of the fuel flow is greater between the said shut-off member (11) and the said opening (18) than upstream of the said shut-off member (11), **characterized in that** the said fuel flow deviation means comprise a first hydraulic resistance (22) downstream of the said shut-off member (11), connected in series with the said outlet duct (10), and a second hydraulic resistance (21) downstream of the said shut-off member (11), arranged in series both with the said opening (18) and with the said outlet duct (10), the value of the said first hydraulic resistance (22) being greater than that of the said second hydraulic resistance (21).

2. Pump according to Claim 1, **characterized in that** a second contact surface (20) is present inside the said seat (7) for delimiting the axial travel of the said shut-off member (11) in the direction which increases the stress of the said spring (12) and **in that** the said second hydraulic resistance (21) is defined by the said second contact surface (20).

3. Pump according to one of Claims 1 or 2, **characterized in that** it comprises a hollow body (15) mounted inside the said seat (7) and defining a cavity (17) for housing the said spring (12) and the said second hydraulic resistance (21).

4. Pump according to Claims 2 and 3, **characterized in that** the said hollow body (15) comprises an end portion (19) defining the said second contact surface (20).

5. Pump according to Claim 4, **characterized in that** the said second hydraulic resistance (21) comprises at least one second opening (21) defined by the said end portion (19).

6. Pump according to any one of Claims 3 to 5, **characterized In that** the said first hydraulic resistance (22) is defined between the said hollow body (15) and a side wall (8) of the said seat (7).

7. Pump according to any one of Claims 3 to 6, **characterized in that** the said hollow body (15) is mounted with radial play inside the said seat (7) and is removable.

8. Pump according to any one of the preceding claims, **characterized in that** the said spring (12) is arranged between the said shut-off member (12) and the said opening (18).

9. Pump according to any one of the preceding claims, **characterized in that** the said opening (18) has a diameter smaller than the maximum dimension of the said shut-off member (12).

10. Pump according to any one of the preceding claims, **characterized in that** the said spring (12) is of the coil type and **in that** the said fuel flow deviation means (21, 22) are configured so that most of the fuel flow which flows towards the said seat (7) passes through the coils of the said spring (12).

11. Pump according to any one of the preceding claims, **characterized in that** the said outlet duct (10) is transverse with respect to the said seat (7) and **in that** the said opening (18) is axially arranged between the said shut-off member (11) and the said outlet duct (10).

Patentansprüche

1. Pumpe für ein Kraftstoffeinspritzsystem eines Verbrennungsmotors, umfassend: einen Sitz (7), der mit der Ausgabe eines Verdichtungsraums (2) strömungsverbunden ist und eine Achse (B) aufweist, einen Auslasskanal (10) zur Verbindung des Sitzes (7) mit mehreren Einspritzdüsen, ein Verschlussglied (11), das in dem Sitz (7) untergebracht ist, eine Feder (12) zur Vorspannung des Verschlussglieds (11) gegen eine erste Kontaktfläche (9) des Sitzes (7) in eine geschlossene Stellung, wobei die Feder (12) stromabwärts des Verschlussglieds (11) angeordnet ist, wobei eine erste Durchgangsöffnung (18) in Axialrichtung, die stromabwärts des Verschlussglieds (11) angeordnet ist, in dem Sitz (7) ausgebildet ist, und wobei sie Kraftstoffstromumlenkmittel (21, 22) umfasst, die in dem Sitz (7) stromaufwärts des Auslasskanals (10) angeordnet sind und so kon-

figuriert sind, dass die Geschwindigkeit des Kraftstoffstroms zwischen dem Verschlussglied (11) und der Öffnung (18) größer ist als stromaufwärts des Verschlussglieds (11), **dadurch gekennzeichnet, dass** die Kraftstoffstromumlenkmittel einen ersten hydraulischen Widerstand (22) stromabwärts des Verschlussglieds (11), der mit dem Auslasskanal (10) in Reihe geschaltet ist, und einen zweiten hydraulischen Widerstand (21) stromabwärts des Verschlussglieds (11), der sowohl mit der Öffnung (18) als auch mit dem Auslasskanal (10) in Reihe geschaltet ist, umfassen, wobei der Wert des ersten hydraulischen Widerstands (22) größer ist als der des zweiten hydraulischen Widerstands (21).

2. Pumpe nach Anspruch 1, **dadurch gekennzeichnet, dass** eine zweite Kontaktfläche (20) in dem Sitz (7) zur Begrenzung des Axialhubs des Verschlussglieds (11) in die Richtung, die die Spannung der Feder (12) erhöht, vorgesehen ist und dass der zweite hydraulische Widerstand (21) durch die zweite Kontaktfläche (20) definiert wird.

3. Pumpe nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** sie einen Hohlkörper (15) umfasst, der in dem Sitz (7) angebracht ist und einen Hohlraum (17) zur Unterbringung der Feder (12) und des zweiten hydraulischen Widerstands (21) definiert.

4. Pumpe nach den Ansprüchen 2 und 3, **dadurch gekennzeichnet, dass** der Hohlkörper (15) einen Endteil (19) umfasst, der die zweite Kontaktfläche (20) definiert.

5. Pumpe nach Anspruch 4, **dadurch gekennzeichnet, dass** der zweite hydraulische Widerstand (21) mindestens eine zweite Öffnung (21) umfasst, die durch den Endteil (19) definiert wird.

6. Pumpe nach einem der Ansprüche 3 bis 5, **dadurch gekennzeichnet, dass** der erste hydraulische Widerstand (22) zwischen dem Hohlkörper (15) und einer Seitenwand (8) des Sitzes (7) definiert ist.

7. Pumpe nach einem der Ansprüche 3 bis 6, **dadurch gekennzeichnet, dass** der Hohlkörper (15) mit radialem Spiel in dem Sitz (7) angebracht und entfernbar ist.

8. Pumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Feder (12) zwischen dem Verschlussglied (11) und der Öffnung (18) angeordnet ist.

9. Pumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Öffnung (18) einen Durchmesser aufweist, der kleiner ist als die maximale Abmessung des Verschlussglieds (11).

10. Pumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Feder (12) eine Spiralfeder ist und dass die Kraftstoffstromumlenkmittel (21, 22) so konfiguriert sind, dass der Großteil des Kraftstoffstroms, der zu dem Sitz (7) fließt, die Spiralen der Feder (12) durchströmt.

11. Pumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Auslasskanal (10) bezüglich des Sitzes (7) quer verläuft und dass die Öffnung (18) axial zwischen dem Verschlussglied (11) und dem Auslasskanal (10) angeordnet ist.

Revendications

1. Pompe pour un système d'injection de carburant d'un moteur à combustion interne, comprenant un siège (7) connecté fluidiquement à l'alimentation d'une chambre de compression (2) et ayant un axe (B), un conduit de sortie (10) pour relier ledit siège (7) à une pluralité d'injecteurs, un organe d'arrêt (11) logé à l'intérieur dudit siège (7), un ressort (12) pour solliciter ledit organe d'arrêt (11) contre une première surface de contact (9) dudit siège (7) dans une position fermée, ledit ressort (12) étant agencé en aval dudit organe d'arrêt (11), une première ouverture traversante (18) dans la direction axiale, agencée en aval dudit organe d'arrêt (11), étant prévue à l'intérieur dudit siège (7) et comprenant des moyens de déviation du flux de carburant (21, 22) agencé à l'intérieur dudit siège (7) en amont dudit conduit de sortie (10) et configuré de telle sorte que la vitesse du flux de carburant soit plus importante entre ledit organe d'arrêt (11) et ladite ouverture (18) qu'en amont dudit organe d'arrêt (11), **caractérisée en ce que** lesdits moyens de déviation du flux de carburant comprennent une première résistance hydraulique (22) en aval dudit organe d'arrêt (11), connectée en série avec ledit conduit de sortie (10), et une deuxième résistance hydraulique (21) en aval dudit organe d'arrêt (11), agencée en série avec à la fois ladite ouverture (18) et ledit conduit de sortie (10), la valeur de ladite première résistance hydraulique (22) étant supérieure à celle de ladite deuxième résistance hydraulique (21).

2. Pompe selon la revendication 1, **caractérisée en ce qu'**une deuxième surface de contact (20) est prévue à l'intérieur dudit siège (7) pour délimiter la course axiale dudit organe d'arrêt (11) dans la direction d'augmentation de la contrainte dudit ressort (12) et **en ce que** ladite deuxième résistance hydraulique (21) est définie par ladite deuxième surface de contact (20).

3. Pompe selon la revendication 1 ou 2, **caractérisée en ce qu'**elle comprend un corps creux (15) monté

à l'intérieur dudit siège (7) et définissant une cavité (17) pour recevoir ledit ressort (12) et ladite deuxième résistance hydraulique (21).

4. Pompe selon les revendications 2 et 3, **caractérisée en ce que** ledit corps creux (15) comprend une portion d'extrémité (19) définissant ladite deuxième surface de contact (20).

5. Pompe selon la revendication 4, **caractérisée en ce que** ladite deuxième résistance hydraulique (21) comprend au moins une deuxième ouverture (21) définie par ladite portion d'extrémité (19).

6. Pompe selon l'une quelconque des revendications 3 à 5, **caractérisée en ce que** ladite première résistance hydraulique (22) est définie entre ledit corps creux (15) et une paroi latérale (8) dudit siège (7).

7. Pompe selon l'une quelconque des revendications 3 à 6, **caractérisée en ce que** ledit corps creux (15) est monté avec un jeu radial à l'intérieur dudit siège (7) et est amovible.

8. Pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ledit ressort (12) est agencé entre ledit organe d'arrêt (12) et ladite ouverture (18).

9. Pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ladite ouverture (18) a un diamètre plus petit que la dimension maximale dudit organe d'arrêt (12).

10. Pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ledit ressort (12) est du type hélicoïdal et **en ce que** lesdits moyens de déviation du flux de carburant (21, 22) sont configurés de telle sorte que la plupart de l'écoulement de carburant qui s'écoule vers ledit siège (7) passe à travers les enroulements dudit ressort (12).

11. Pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** ledit conduit de sortie (10) est transversal par rapport audit siège (7) et **en ce que** ladite ouverture (18) est agencée axialement entre ledit organe d'arrêt (11) et ledit conduit de sortie (10).

FIG. 1

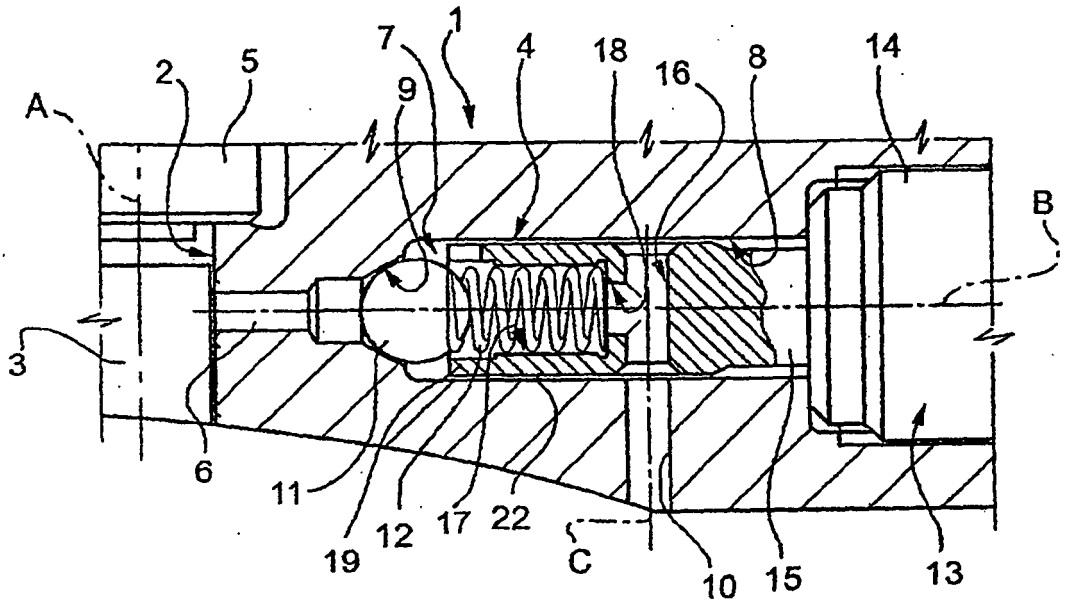
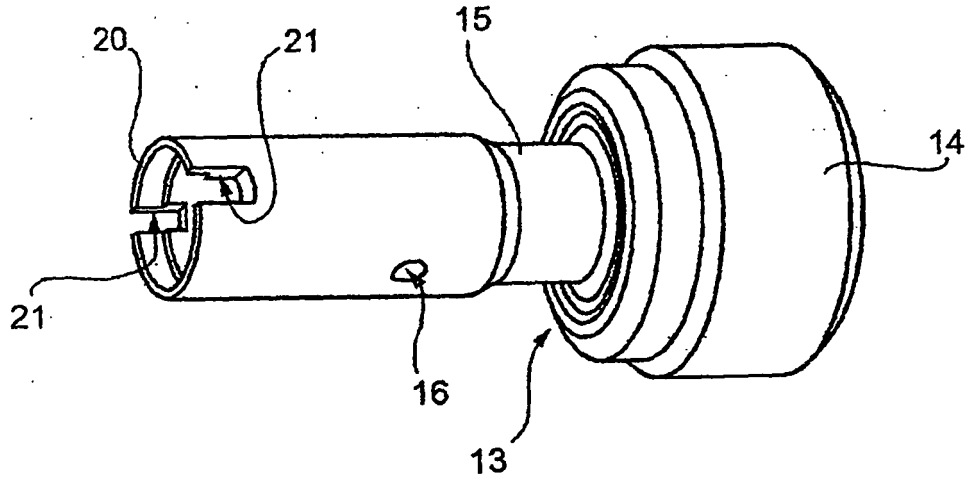


FIG. 2



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- GB 513349 C **[0007]**