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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) Method for producing the sealing seat with injection holes of a fuel injector

(57) Method for producing the sealing seat (11) of a fuel injector (1) for an internal-combustion engine, the sealing seat (11) having a plurality of injection holes (3); the method comprises the steps of: mixing plastic binder with a powdered metal so as to obtain a homogeneous compound; injecting, in order to form the sealing seat (11), the homogeneous compound into a mould (14) that reproduces in negative the shape of the sealing seat (11); obtaining within the mould (14) a plurality of punches (15) that reproduce in negative at least partially the shape of the injection holes (3) in such a way as to form within the mould (14) the sealing seat (11), which already presents the injection holes (3); and subjecting the sealing seat (11) to a thermal treatment to eliminate the plastic binder and sinter the powdered metal.

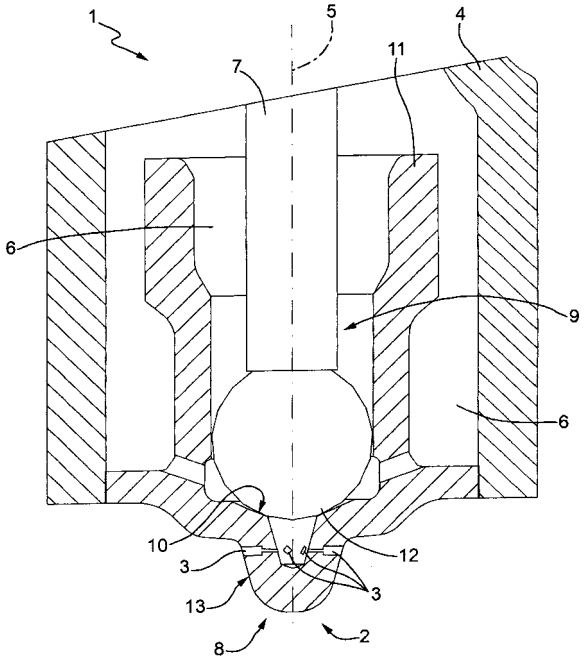


FIG.1

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Description

TECHNICAL FIELD

[0001] The present invention relates to a method for producing the sealing seat with injection holes of a fuel injector.

BACKGROUND ART

[0002] Normally, a fuel injector for an internal-combustion engine comprises a cylindrical tubular supporting body having a central supply channel, which performs the function of supply channel for the fuel and terminates with an injection nozzle regulated by an injection valve controlled by an electromagnetic actuator. Set within the supply channel is a shutter or "needle", mechanically connected to the electromagnetic actuator to be displaced between a position of closing and a position of opening of the injection nozzle.

[0003] According to a possible embodiment, for regulating the flow of fuel through the injection nozzle, the shutter co-operates with a valve seat of a sealing seat, which closes the supply channel at the bottom and is provided with injection holes.

[0004] Currently, the process of production of the sealing seat of the injector envisages, in a first step, injection moulding in a common mould of a compound formed by plastic binders and powdered metal. Subsequently, after extraction from the mould, the sealing seat undergoes a thermal treatment in furnaces, in which, as a result of the very high temperatures that are reached, the plastic binders melt whilst the powdered metal is compacted to form a sintered metal. As is known, the process of sintering of the metal consists in compacting and transforming materials reduced to powder in an indivisible compound that at this point of the process has the desired characteristics of hardness and strength for the sealing seat.

[0005] In a third step, the injection holes or spot facings are made in the sealing seat using an electric-discharge machine (EDM), in which machining with removal of stock for creating the injection holes uses, as is known, the erosive capabilities of electrical discharges.

[0006] The process of production of the sealing seat so far described presents, however, the drawback of being as a whole very slow and costly, above all because the machining speed of electric-discharge machines (EDMs) is substantially lower than that of other technologies with removal of stock.

DISCLOSURE OF INVENTION

[0007] Aim of the present invention is to provide a method for the production of a sealing seat with injection holes of a fuel injector that does not present the drawbacks described above and in particular is easy and inexpensive to implement.

[0008] Provided according to the present invention is a method for producing the sealing seat with injection holes of a fuel injector according to what is claimed in the annexed claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention will now be described with reference to the annexed drawings, which illustrate a non-limiting example of embodiment thereof and in which:

Figure 1 is a schematic sectioned view of a detail of a fuel injector having a sealing seat obtained by means of the production method forming the subject of the present invention;
Figure 2 is a perspective view in elevation of the sealing seat of Figure 1; and
Figure 3 is a cross-sectional view of a mould of an injection press used for making the sealing seat of Figure 1.

PREFERRED EMBODIMENTS OF THE INVENTION

[0010] Designated as a whole by 1 in Figure 1 is a fuel injector, which has, at one end thereof, an injection nozzle 2 provided with injection holes 3 and is controlled for injecting fuel directly into a combustion chamber (not illustrated) of a cylinder (not illustrated).

[0011] In greater detail, the injector 1 comprises a supporting body 4 having a cylindrical tubular shape, which has a longitudinal axis 5 and defines a supply channel 6 for the fuel, which extends throughout the length of the supporting body 4 for supplying the fuel under pressure to the injection nozzle 2.

[0012] The supporting body 4 houses within it an electromagnetic actuator (not illustrated) for actuation of a shutter 7 or "needle", which is designed to regulate the flow of fuel through the injection nozzle 2 and has a top end, which is integral with the electromagnetic actuator (not illustrated). In a position corresponding to a bottom end thereof, the supporting body 4 houses an injection valve 8, which, under the action of the electromagnetic actuator (not illustrated), regulates the flow of fuel that traverses the injection nozzle 2.

[0013] The shutter 7 is mobile along the axis 5 and a bottom end 9 thereof co-operates, in a closing position of the injection valve 8, with a valve seat 10 of a sealing seat 11. The bottom portion 9 of the shutter 7 is housed within the supply channel 6 and terminates with an plugging head 12 having a substantially spherical shape, which is designed to engage the valve seat 9 in the closing position of the injection valve 8.

[0014] According to what is illustrated more fully in Figure 2, the sealing seat 11 is defined by a monolithic body having a bottom portion designed to close at the bottom in a sealed way the supply channel 6 for the fuel and a top tubular portion that functions as guide for the bottom portion 9 of the shutter 7. The injection nozzle 2 is made

immediately downstream of the injection valve 8 and is defined by the plurality of through injection holes 3, which are distributed about the longitudinal axis 5 and are made on an outer conical surface 13 of the bottom portion of the sealing seat 11.

[0015] In the stage of assembly of the injector 1, all the components are produced independently and pre-assembled in different groups prior to final assembly. In the final structure of the injector 1, in order to guarantee sealing of the welds and to follow the local deformability of some components subjected to heating, the different pre-assembled groups are mounted with interposition of different seal rings that meet these needs and increase the strength of the injector 1.

[0016] The sealing seat 11 of the injector 1 constitutes one of the different units that are produced independently and assembled in the final stage of the process of production of the injector 1 and is obtained entirely with metal-injection-moulding (MIM) technology.

[0017] For the production of the sealing seat 11, starting powdered metal is mixed in defined percentages with a plastic binder in order to obtain a homogeneous compound, which is then machined in the subsequent steps of the process.

[0018] In particular, the first step of the MIM process consists in injection into a mould 14 (partially illustrated in Figure 3) of said mixture at controlled temperature and pressure. According to a known injection-moulding technique, the homogeneous starting compound (i.e., metal and plastic binder) is heated up to fluidification in an injection press, injected at low pressure into the mould 14, which reproduces in negative the shape of the sealing seat 11, then left to cool off up to solidification, and finally extracted from the mould 14.

[0019] The mould 14 is formed by joining two half-moulds together and is provided with punches 15, which reproduce the shape of the injection holes 3 to be obtained. In this way, within the mould 14 the injection holes 3 are formed directly on the conical surface 13 of the semifinished sealing seat 11. According to a preferred embodiment, each injection hole 3 comprises an outer portion of larger diameter and an inner portion of smaller diameter, and the punches 15 are shaped for reproducing in negative only the outer portion of each injection hole 3.

[0020] The semi-finished sealing seat 11 obtained after the injection-moulding are oversized with respect to the nominal dimensions of the finished sealing seat 11 on account of the reduction of dimensions that takes place in the subsequent steps. In fact, the sealing seats 11, in a second step of the process, undergo a thermal process to obtain almost complete elimination of the plastic binder without any fractures or deformations of the sealing seat 11 itself. Basically, the elimination of the binder is the operation performed for removing the plastic polymers from the powdered metal, and the method used is determined by the physical properties of the metal, by the requirements of the finished product, i.e., the sealing seat 11, and by the chemical composition. The semifinished pieces coming off the injection press are inserted in furnaces for removal of the binder, which usually occurs by evaporation. When the process is completed, there is obtained a semifinished piece made of powdered metal, which, in a further step, must be deprived of the residual plastic binder by sintering. Sintering of the sealing seat 11 bestows the required mechanical and geometrical properties upon the sealing seats 11 and certainly constitutes the most delicate point of MIM technology. With sintering, in fact, the material must obtain the desired properties and dimensions. During this step, very high temperatures are reached, which cause a uniform shrinkage of the sealing seat 11. The process of production of the sealing seat 11 terminates with the step of mechanical drilling of the sealing seat 11 itself to provide the inner portion of each injection hole 3.

[0021] The process of production described above presents numerous advantages. In the first place, it enables maximum freedom of design in so far as by means of the injection of powdered metal it is possible to obtain sealing seats 11 of even very complex shapes, with particularly reduced dimensional tolerances and with highly automated production cycles. Furthermore, the process of production described above is particularly convenient in the presence of high production volumes and in general enables a sensible reduction of the production costs as a result of a reduction of the machining operations to which the sealing seat 11 must be subjected; said sealing seat 11, at the end of the machining cycle performed with MIM technology, is already finished and ready to be assembled without any further machining operations (or merely requires simple mechanical drilling).

[0022] It should be noted that, on account of the reduced size of the injection holes 3 (which have a diameter and a longitudinal extension of the order of tenths of millimetre) it is not possible to make the injection holes 3 entirely using the punches 15. Instead, by making the outer portions of larger diameter of the injection holes 3 directly within the mould 14 by the presence of the punches 15 it is possible to complete the injection holes 3 by making the inner portions of smaller diameter by means of a simple drilling operation (using a rotary drill or else by shearing or electric-discharge machining of the remaining thickness) with considerable advantages both in terms of reduction of the costs of equipment due to a smaller number of drilling stations necessary, and in terms of reduction of the machining times due to the extremely small thickness to be drilled.

Claims

1. A method for producing the sealing seat (11) of a fuel injector (1) for an internal-combustion engine, said sealing seat (11) having a plurality of injection holes (3); the method comprising the steps of:

   mixing plastic binder with a powdered metal so

as to obtain a homogeneous compound;
injecting, in order to form the sealing seat (11), the homogeneous compound in a mould (14) that reproduces in negative the shape of the sealing seat (11); and
subjecting the sealing seat (11) to a thermal treatment to eliminate the plastic binder and sinter the powdered metal;
the production method being **characterized in that** it comprises the further step of:

obtaining within the mould (14) a plurality of punches (15) that reproduce in negative at least partially the shape of the injection holes (3) in such a way as to form within the mould (14) the sealing seat (11), which already presents the injection holes (3).

2. Production method according to Claim 1, wherein the step of subjecting the sealing seat (11) to a thermal treatment comprises the further steps of:

subjecting the sealing seat (11) to a first heating to eliminate the plastic binder at least partially; and
subjecting the sealing seat (11) to a subsequent second heating at temperatures higher than that for the first heating to eliminate the residual plastic binder and sinter the powdered metal.

3. Production method according to Claim 1 or Claim 2, wherein each injection hole (3) comprises an outer portion of larger diameter and an inner portion of smaller diameter.

4. Production method according to Claim 3, wherein each punch (15) reproduces in negative only the outer portion of larger diameter of a respective injection hole (3); the production method comprising the further step of drilling mechanically the sealing seat (11) in correspondence of each injection hole (3) for providing the inner portion of the injection hole (3) itself.

5. Production method according to Claim 4, wherein the inner portion of each injection hole (3) of the sealing seat (11) is obtained by means of electric-discharge machining.

6. Production method according to Claim 4, wherein the inner portion of each injection hole (3) of the sealing seat (11) is obtained by shearing.

7. The production method according to Claim 4, wherein the inner portion of each injection hole (3) of the sealing seat (11) is obtained by means of a rotary drill.

Amended claims in accordance with Rule 137(2) EPC.

1. A method for producing the sealing seat (11) of a fuel injector (1) for an internal-combustion engine, said sealing seat (11) having a plurality of injection holes (3); the method comprising the steps of:

mixing plastic binder with a powdered metal so as to obtain a homogeneous compound;
injecting, in order to form the sealing seat (11), the homogeneous compound in a mould (14) that reproduces in negative the shape of the sealing seat (11);
obtaining within the mould (14) a plurality of punches (15) that reproduce in negative at least partially the shape of the injection holes (3) in such a way as to form within the mould (14) the sealing seat (11), which already presents the injection holes (3); and
subjecting the sealing seat (11) to a thermal treatment to eliminate the plastic binder and sinter the powdered metal;
the production method being **characterized in that**:

each injection hole (3) comprises an outer portion of larger diameter and an inner portion of smaller diameter;
each punch (15) reproduces in negative only the outer portion of larger diameter of a respective injection hole (3); and
the production method comprises the further step of drilling mechanically the sealing seat (11) in correspondence of each injection hole (3) for providing the inner portion of the injection hole (3).

2. Production method according to Claim 1, wherein the step of subjecting the sealing seat (11) to a thermal treatment comprises the further steps of:

subjecting the sealing seat (11) to a first heating to eliminate the plastic binder at least partially; and
subjecting the sealing seat (11) to a subsequent second heating at temperatures higher than that for the first heating to eliminate the residual plastic binder and sinter the powdered metal.

3. Production method according to Claim 1 or 2, wherein the inner portion of each injection hole (3) of the sealing seat (11) is obtained by means of electric-discharge machining.

4. Production method according to Claim 1 or 2, wherein the inner portion of each injection hole (3) of the sealing seat (11) is obtained by shearing.

5. The production method according to Claim 1 or 2, wherein the inner portion of each injection hole (3) of the sealing seat (11) is obtained by means of a rotary drill.

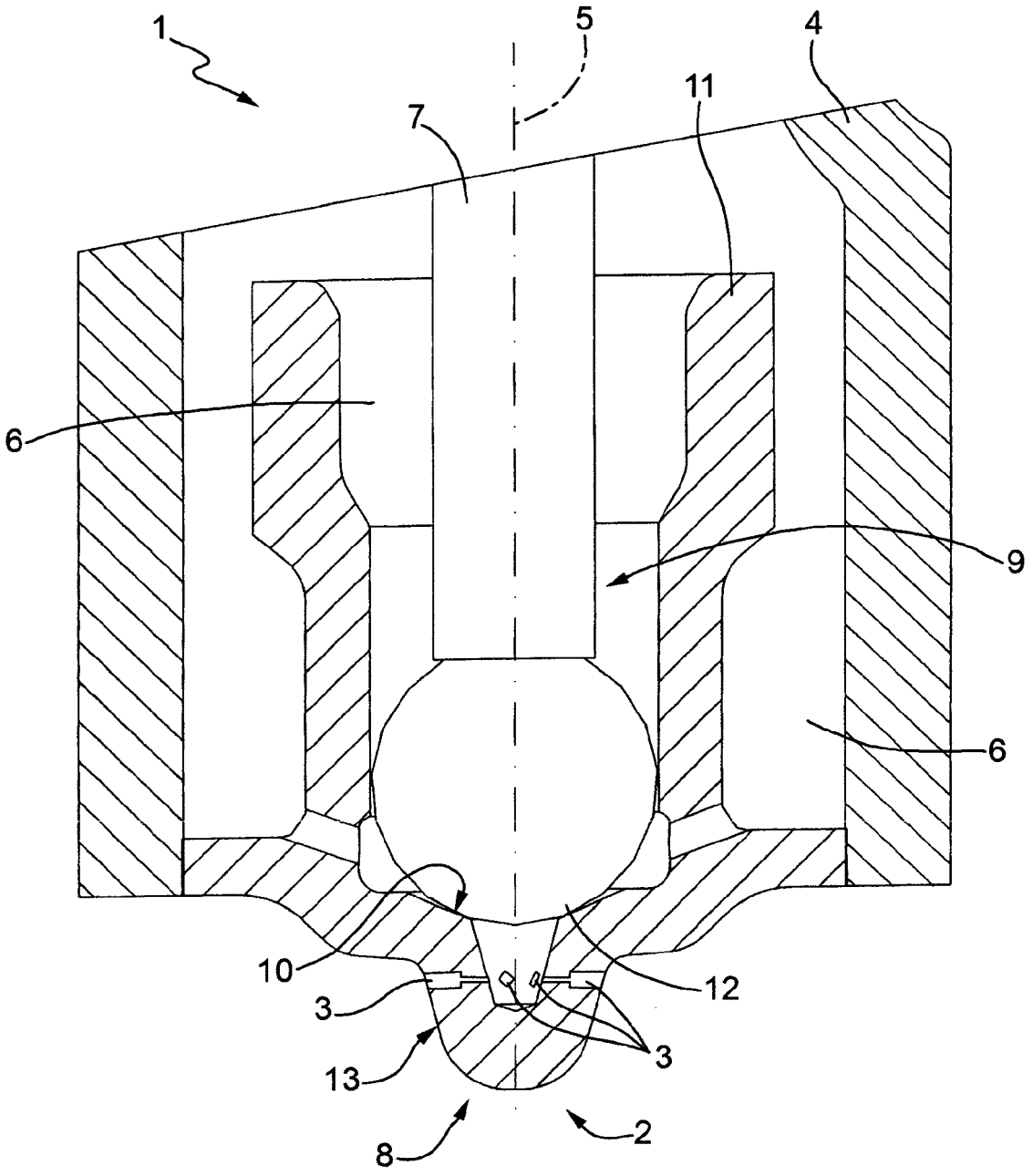


FIG.1

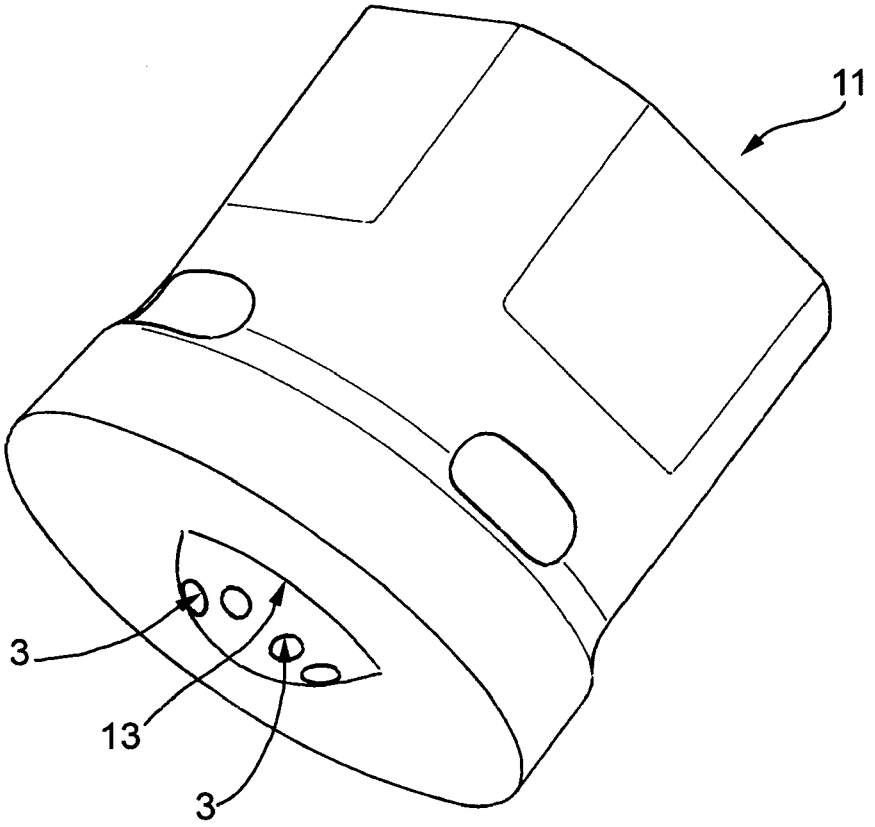


FIG.2

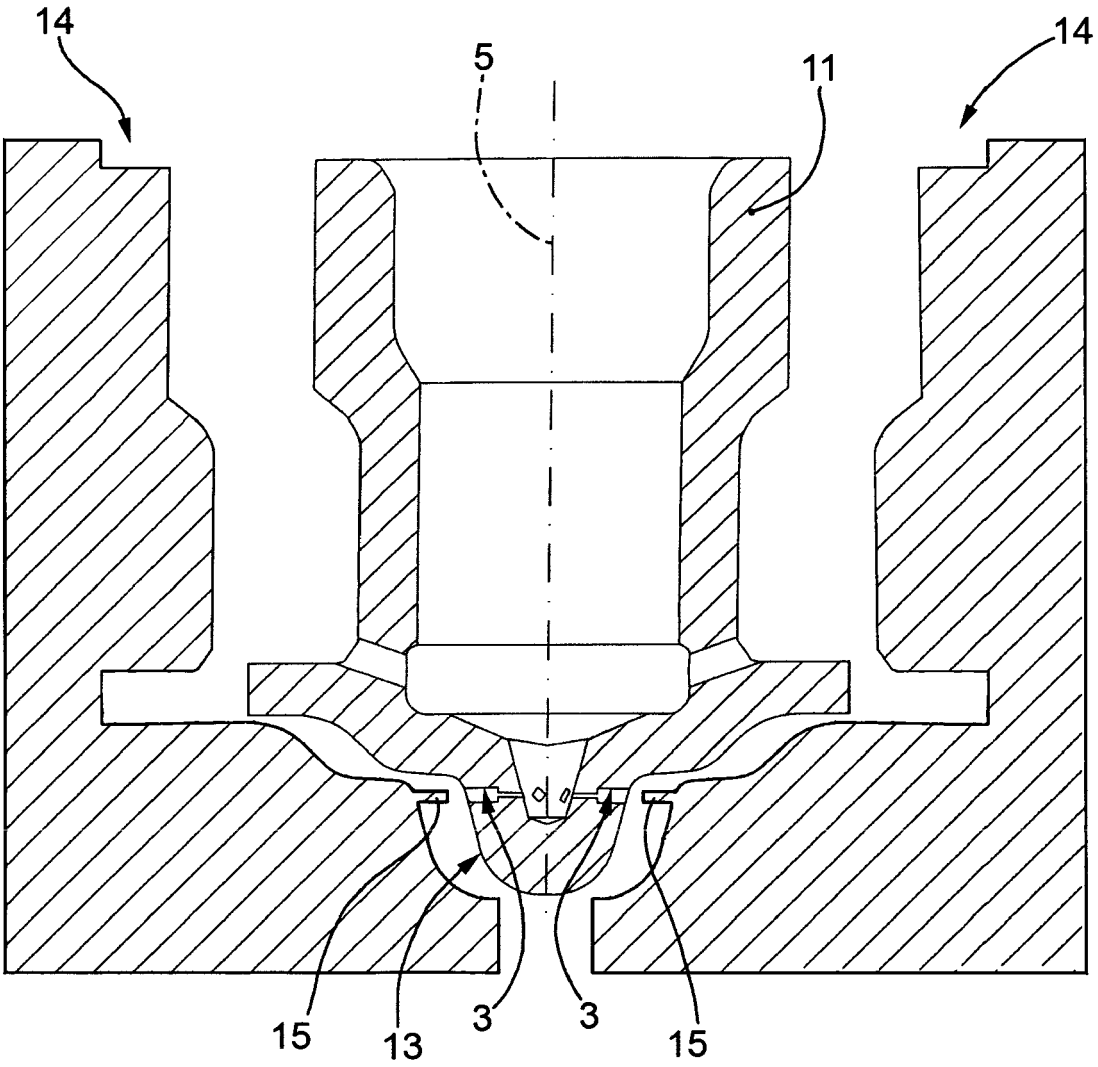


FIG.3

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EUROPEAN SEARCH REPORT

Application Number
EP 08 42 5800

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 01/48371 A (BOSCH GMBH ROBERT [DE]; RUTHARDT SIEGFRIED [DE]; RAPP HOLGER [DE]; GRY) 5 July 2001 (2001-07-05) * page 3, line 19 - page 4, line 6; figures 1-3 *	1-7	INV. F02M61/16 F02M61/18
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			TECHNICAL FIELDS SEARCHED (IPC)
			F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	20 May 2009	Etschmann, Georg

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 08 42 5800

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20-05-2009

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82