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(54) **Metering device with flow calibrator and method for setting a flow rate of a metering device**

Messvorrichtung mit Durchfluss-Kalibriereinrichtung sowie Verfahren zur Einstellung der Durchflussmenge der Messvorrichtung

Dispositif de dosage avec calibre du débit et procédé pour ajuster le débit du dispositif de dosage

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US-A- 5 232 167 **US-B1- 6 385 848**

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Description

[0001] The present invention relates to a metering device for dosing pressurized fluids, particularly an injection valve for a fuel injection system in an internal combustion engine. The metering device is of the type which comprises a housing having an end part provided with an outlet passage terminating with a metering opening, an axially moveable valve needle passing through the outlet passage and controlling opening and closing of the metering opening, and a piezoelectric actuator in axial alignment with the valve needle and cooperating with the valve needle to control its axial movement. The invention further relates to a method for setting a flow rate of such a metering device.

[0002] The European Patent application EP 1 046 809 A2 discloses an injection valve of this type. For these injection valves it is essential that the flow rate delivered by the injector can be set to a defined value at the end of the assembly process in the factory. Presently, the calibration of such an injector is carried out in a state where the injector is not completely assembled and welded.

[0003] The injector to be calibrated is introduced in an appropriate blocking tool. The regulation of the flow rate through the injector is carried out by inserting one or more calibrated spacer rings in the valve spring blockage and repeatedly measuring the flow rate until a desired flow rate is reached. After the calibration process is completed, the injector proceeds to the final welding of the inlet fitting on the housing. Such an iterative operational sequence is time consuming and expensive and may not be adapted to the mass production in a factory.

[0004] The current process is also extremely complex, because several process variables such as the length and the elongation of the piezoelectric stack, the dimensional tolerances of the parts involved, and the chamber height of the thermal compensator have to be taken into account. Further, as the spacer rings have to be changed repeatedly, it is not possible to calibrate the injector during a flow phase of the fluid.

[0005] A major drawback of the current solution arises from the inability to adjust the flow of the injector after the completion of the whole assembly process. The current type of flow adjustment is feasible only before the final welding of the housing and the valve body of the injector. Therefore, if it is found in the post calibration run that an injector does not meet the flow requirements, no further corrections are possible, and the injector has to be discarded.

[0006] DE 37 35 288 A1 discloses an electromagnetic fuel injection valve with a beam which is fixed to a valve upper part by laser welding. The injection now further comprises a needle, which is preloaded into a closing position by a spring. In addition to that a coil is provided being part of an electromagnetic circuit exerting a force on the needle if a current is applied to the coil. For adjusting a lift of the needle punches are pushed through

recesses of the valve upper body to plastically deform the beam and in that way to change its axial length.

[0007] WO 01/90570 A1 discloses a fuel injector with a check valve member, which is hydraulically operated by respectively changing a pressure of a fuel. In order to perform a preinjection or a microinjection a solid state motor is provided to lower a check stop, so that when fuel pressure in the nozzle chamber is raised the check valve member is limited to lift a much smaller distance.

[0008] US 6,385,848 B1 discloses a method of setting a distance between a first body and a second body in a fuel injector. The method includes providing an intermediate body having a first end, a second end and a longitudinal axis, the first end being fixedly connected to the first body and a second end being fixedly connected to the second body. The intermediate body is compressed towards the longitudinal axis. The compression axially elongates the intermediate body such that the first body is separated from the second body.

[0009] DE 199 32 762 A1 discloses an injection valve with a needle, that rests in a closing position on a seat, the seat being connected to a valve seat carrier. The valve seat carrier is plastically deformed in order to change the lift of the needle.

[0010] In view of the foregoing, it is an object of the present invention to improve the flow adjustment process for a metering device of the above mentioned type.

[0011] This object is achieved by a metering device with the features of appended claim 1, and by the method for setting a flow rate of a metering device of independent claim 8.

[0012] Advantageous embodiments of the invention are disclosed in the dependent claims.

[0013] According to the invention, in a metering device of the type mentioned above, a plastically deformed adjustment element is arranged axially aligned between a bottom end piece of the piezoelectric actuator and a head of the valve needle, wherein a plastic deformation of the adjustment element regulates the axial spacing between the piezoelectric actuator and the valve needle, thereby setting a flow rate for the metering device.

[0014] The invention is thus based on the idea to provide a deformable adjustment element in the metering device allowing for a flow rate calibration even after the metering device is completely assembled.

[0015] In a preferred embodiment of the invention, the adjustment element comprises a metal element shaped such that a radial compression of the element causes an axial elongation thereof. The flow rate can then be set by driving two or more shaped punches radially inward through the housing of the metering device, thereby radially compressing and axially elongating the adjustment element. As the relative movement of the upper and lower face of the metal element is based on a controlled deformation of the metal element, the desired lift of the needle and thus the desired flow rate can be achieved.

[0016] Advantageously, the adjustment element has a first contact area for mounting the adjustment element

to the bottom end piece of the piezoelectric actuator, a plastically deformable crimping area, the radial compression of which causes an axial elongation of the adjustment element, and a second contact area for contacting the head of the valve needle.

[0017] In a further preferred embodiment of the invention, the first contact area of the adjustment element and the bottom end piece of the piezoelectric actuator comprise corresponding engagement means to mount the adjustment element to the piezoelectric actuator.

[0018] The second contact area of the adjustment element may advantageously comprise a hardened hemispherical head pin to provide good contact with the needle head.

[0019] In an especially preferred embodiment, the adjustment element is formed as a hollow frustoconical and biconical body with a central cylindrical area.

[0020] Preferably, two or more through holes are provided in the housing of the metering device, which are radially aligned with a crimping area of the adjustment element. The through holes provide access to the adjustment element and allowing plastic deformation thereof after the complete assembly of the metering device.

[0021] According to the invention, in a method for setting a flow rate of any of the metering devices described above, the flow rate through a completely assembled metering device is repeatedly measured and the adjustment element is gradually radially compressed until a predetermined flow rate through the metering device is achieved.

[0022] In order to radially compress the adjustment element, preferably one or more punches are inserted in the through holes of the housing and driven inwardly, thereby inducing an axial adjustment of the spacing between the piezoelectric actuator and the valve needle.

[0023] In a preferred embodiment, the punch or the punches are driven inwardly by imposed strokes. Alternatively, the punch or the punches may be driven inwardly by an imposed load.

[0024] The advantages gained by the technical features of the invention include

- an easy method for precisely setting the desired flow rate of an injector;
- the possibility to calibrate the flow rate after the completed assembly of the injector; and
- the possibility to adapt the method in a mass production process for metering devices.

[0025] The invention, both its construction and its method of operation together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in connection with the accompanying drawings, wherein

Figure 1 is a schematic axial cross section of the lower

part of an injector valve according to an embodiment of the invention;

Figure 2 is a close-up view of the adjustment element shown in Fig. 1; and

Figure 3 is an exploded view of the parts of the adjustment element together with the piezoelectric actuator of Fig. 1.

[0026] Figure 1 illustrates an injection valve 10 for direct-injection gasoline engines. The injection valve 10 has a housing 12, whose lower part has an outlet passage 14 terminating with a metering opening 16.

[0027] Among other elements that are not pertinent to the present invention, the housing 12 contains a piezoelectric actuator 18. An excitation voltage is applied to the piezoelectric actuator 18 to open the injection valve 10 and inject gasoline into the engine cylinder. In response to the excitation voltage, the piezoelectric actuator 18 increases in length in axial direction by a predetermined amount. The length extension is transmitted to a valve needle 20 disposed in the outlet passage 14. The needle 20 depresses a biasing spring and lifts from its seat to start the injection of pressurized gasoline in the engine cylinder. When the excitation voltage is terminated, the length of the piezoelectric actuator 18 decreases to its normal value and the valve needle 20 is pushed back in its closing position.

[0028] In the embodiment of Fig. 1, a plastically deformable adjustment element 22 is arranged axially aligned between a bottom action cap 24 of the piezoelectric actuator 18 and a head 26 of the valve needle 20. As best seen in the close-up view of Fig. 2, the adjustment element 22 is formed as a hollow frustoconical and biconical metal body 30 with a central cylindrical area 32. As evident from Fig. 2, the metal body 30 has a shape for which a radial compression of the body 30 causes an axial elongation of the adjustment element 22.

[0029] Fig. 3 shows an exploded view of the adjustment element 22 together with the piezoelectric actuator 18. The bottom end piece 24 of the piezoelectric actuator 18 comprises an engagement element 38, which allows the metal body 30 to be easily mounted to the piezoelectric actuator 18 by geometrical interference of the contact area 39 (Fig. 2) of the adjustment element 22 with the corresponding engagement element 38.

[0030] The adjustment element 22 further comprises a hardened hemispherical head pin 34 to optimize the contact with the needle head 26. As the piezoelectric actuator 18, the hemispherical head pin 34 comprises an engagement element 36 allowing the metal body 30 to be easily mounted to the hemispherical head pin 34 by geometrical interference.

[0031] Now again with reference to Fig. 1, two through holes 28 and 29 are provided in the housing 12 of the injection valve 10 to provide access to the adjustment element 22 and allowing plastic deformation thereof after

the complete assembly of the injection valve 10. The two through holes 28 and 29 are radially aligned with the central crimping area 32 of the adjustment element and are spaced by 180° along the circumference of the housing 12. While only two through holes are shown in the embodiment of Fig. 1, it will be appreciated that three or more appropriately spaced through holes may be provided in the housing 12 as well.

[0032] The flow rate of the injector valve 10 can then be adjusted after it is completely assembled and welded. In this state the through holes 28 and 29 are initially closed by plastic plugs for packaging purposes.

[0033] At first, the pre-adjusted lift and/or flow rate is measured. If the desired flow rate is not attained, the plastic plugs are removed and one or more punches are inserted in the through holes 28 and 29 and driven inwardly by applying strokes or a constant load. Thereby, the metal body 30 of the adjustment element 22 is gradually deformed.

[0034] The resulting plastic deformation of the metal body caused by the action of the punches induces an axial elongation of the adjustment element 22 and therefore increases the spacing between the piezoelectric actuator 18 and the needle 20. As the relative movement of the upper and lower face of the metal body 30 is based on a controlled deformation, the desired lift and the desired flow rate can be achieved.

Claims

1. A metering device for dosing pressurized fluids, particularly an injection valve for a fuel injection system in an internal combustion engine, comprising

- a housing (12) having an end part provided with an outlet passage (14) terminating with a metering opening (16),
- an axially moveable valve needle (20) passing through the outlet passage (14), and controlling opening and closing of the metering opening (16), and
- a piezoelectric actuator (18) in axial alignment with the valve needle (20) and cooperating with the valve needle (20) to control its axial movement,

characterized in that

a plastically deformed adjustment element (22) is arranged axially aligned between a bottom end piece (24) of the piezoelectric actuator (18) and a head (26) of the valve needle (20), wherein a plastic deformation of the adjustment element (22) regulates the axial spacing between the piezoelectric actuator (18) and the valve needle (20), thereby setting a flow rate for the metering device.

2. The metering device according to claim 1,

characterized in that

the adjustment element (22) comprises a metal element (30, 32) shaped such that a radial compression of the element causes an axial elongation thereof.

3. The metering device according to claim 1 or 2,

characterized in that

the adjustment element (22) has a first contact area for mounting the adjustment elements (22) to the bottom end piece (24) of the piezoelectric actuator (18), a plastically deformable crimping area (30, 32), the radial compression of which causes an axial elongation of the adjustment element (22), and a second contact area (34) for contacting the head (26) of the valve needle (20).

4. The metering device according to claim 3,

characterized in that

the first contact area of the adjustment element (22) and the bottom end piece (24) of the piezoelectric actuator (18) comprise corresponding engagement means (38, 39) to mount the adjustment element (22) to the piezoelectric actuator (18).

5. The metering device according to claim 3,

characterized in that

the second contact area of the adjustment element (22) comprises a hardened hemispherical head pin (34) to provide good contact with the needle head (26).

6. The metering device according to any of the preceding claims,

characterized in that

the adjustment element (22) is formed as a hollow frustoconical and biconical body (30) with a central cylindrical area (32).

7. The metering device according to any of the preceding claims,

characterized in that

two or more through holes (28, 29) are provided in the housing (12) of the metering device (10), radially aligned with a crimping area (30, 32) of the adjustment element (22), the through holes (28, 29) providing access to the adjustment element (22) and allowing plastic deformation thereof after the complete assembly of the metering device.

8. A method for setting a flow rate of a metering device according to any of the preceding claims, wherein the flow rate through a completely assembled metering device is repeatedly measured and the adjustment element is gradually radially compressed until a predetermined flow rate through the metering device is achieved.

9. The method according to claim 8,

characterized in that

in order to radially compress the adjustment element, one or more punches are inserted in the through holes of the housing and driven inwardly, thereby inducing an axial adjustment of the spacing between the piezoelectric actuator and the valve needle.

10. The method according to claim 9,

characterized in that

the punch or the punches are driven inwardly by imposed strokes.

11. The method according to claim 9,

characterized in that

the punch or the punches are driven inwardly by an imposed load.

Patentansprüche

1. Dosiervorrichtung zum Dosieren von unter Druck stehenden Strömungsmitteln, insbesondere Einspritzventil für ein Kraftstoffeinspritzsystem in einer Brennkraftmaschine, mit

- einem Gehäuse (12) mit einem Endteil, der mit einem Auslasskanal (14) versehen ist, welcher mit einer Dosieröffnung (16) endet,
- einer axial beweglichen Ventilnadel (20), die sich durch den Auslasskanal (14) erstreckt und das Öffnen und Schließen der Dosieröffnung (16) steuert, und
- einer piezoelektrischen Betätigungseinheit (18) in axialer Ausrichtung mit der Ventilnadel (20), die mit der Ventilnadel (20) zusammenwirkt, um deren Axialbewegung zu steuern,

dadurch gekennzeichnet, dass ein plastisch verformtes Einstellelement (22) mit axialer Ausrichtung zwischen einem unteren Endteil (24) der piezoelektrischen Betätigungseinheit (18) und einem Kopf (26) der Ventilnadel (20) angeordnet ist, wobei durch eine plastische Verformung des Einstellelementes (22) der axiale Abstand zwischen der piezoelektrischen Betätigungseinheit (18) und der Ventilnadel (20) reguliert und auf diese Weise der Durchsatz der Dosiervorrichtung eingestellt wird.

2. Dosiervorrichtung nach Anspruch 1, **dadurch gekennzeichnet, dass** das Einstellelement (22) ein Metallelement (30, 32) umfasst, das so geformt ist, dass eine radiale Kompression des Elementes eine axiale Auslängung desselben bewirkt.
3. Dosiervorrichtung nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das Einstellelement (22) einen ersten Kontaktbereich zur Montage des Einstellelementes (22) am unteren Endteil (21) der piezo-

elektrischen Betätigungseinheit (18), einen plastisch verformbaren Sickenbereich (30, 32), dessen radiale Kompression eine axiale Auslängung des Einstellelementes (22) bewirkt, und einen zweiten Kontaktbereich (34) zum Kontakt mit dem Kopf (26) der Ventilnadel (20) aufweist.

4. Dosiervorrichtung nach Anspruch 3, **dadurch gekennzeichnet, dass** der erste Kontaktbereich des Einstellelementes (22) und das untere Endteil (24) der piezoelektrischen Betätigungseinheit (18) entsprechende Eingriffsmittel (38, 39) zur Montage des Einstellelementes (22) an der piezoelektrischen Betätigungseinheit (18) umfassen.

5. Dosiervorrichtung nach Anspruch 3, **dadurch gekennzeichnet, dass** der zweite Kontaktbereich des Einstellelementes (22) einen gehärteten halbkugelförmigen Kopfstift (34) aufweist, um einen guten Kontakt mit dem Nadelkopf (26) herzustellen.

6. Dosiervorrichtung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** das Einstellelement (22) als hohler kegelförmiger und bikonischer Körper (30) mit einem zentralen zylindrischen Bereich (32) geformt ist.

7. Dosiervorrichtung nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** zwei oder mehr Durchgangslöcher (28, 29) im Gehäuse (12) der Dosiervorrichtung (10) vorgesehen sind, die radial zu einem Sickenbereich (30, 32) des Einstellelementes (22) ausgerichtet sind, wobei die Durchgangslöcher (28, 29) einen Zugang zum Einstellelement (22) und eine plastische Verformung desselben nach der vollständigen Montage der Dosiervorrichtung ermöglichen.

8. Verfahren zum Einstellen des Durchsatzes einer Dosiervorrichtung nach einem der vorangehenden Ansprüche, bei dem der Durchsatz durch eine vollständig montierte Dosiervorrichtung wiederholt gemessen und das Einstellelement allmählich radial komprimiert wird, bis ein vorgegebener Durchsatz durch die Dosiervorrichtung erreicht ist.

9. Verfahren nach Anspruch 8, **dadurch gekennzeichnet, dass** zum radialen Komprimieren des Einstellelementes ein oder mehrere Stanzwerkzeuge in die Durchgangslöcher des Gehäuses eingesetzt und nach innen getrieben werden, um auf diese Weise eine axiale Einstellung des Abstandes zwischen der piezoelektrischen Betätigungseinheit und der Ventilnadel zu induzieren.

10. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** das Stanzwerkzeug oder die Stanzwerkzeuge durch aufgebrachte Schläge nach innen

getrieben werden.

11. Verfahren nach Anspruch 9, **dadurch gekennzeichnet, dass** das Stanzwerkzeug oder die Stanzwerkzeuge durch eine aufgebrachte Last nach innen getrieben werden.

Revendications

1. Dispositif de dosage pour doser des fluides sous pression, en particulier une soupape d'injection pour un système d'injection de carburant dans un moteur à combustion interne, comprenant :

un boîtier (12) ayant une partie d'extrémité prévue avec un passage de sortie (14) se terminant par une ouverture de dosage (16),
un pointeau (20) de soupape axialement mobile passant par le passage de sortie (14) et contrôlant l'ouverture et la fermeture de l'ouverture de dosage (16), et
un actionneur piézoélectrique (18) en alignement axial avec le pointeau (20) de soupape et coopérant avec le pointeau (20) de soupape pour contrôler son mouvement axial,

caractérisé en ce qu'un élément de réglage (22) plastiquement déformable est agencé de manière axialement alignée entre une pièce d'extrémité inférieure (24) de l'actionneur piézoélectrique (18) et une tête (26) du pointeau (20) de soupape, dans lequel une déformation plastique de l'élément de réglage (22) règle l'espacement axial entre l'actionneur piézoélectrique (18) et le pointeau (20) de soupape, réglant ainsi un débit pour le dispositif de dosage.

2. Dispositif de dosage selon la revendication 1, **caractérisé en ce que** l'élément de réglage (22) comprend un élément métallique (30, 32) formé de sorte qu'une compression radiale de l'élément provoque son allongement axial.
3. Dispositif de dosage selon la revendication 1 ou 2, **caractérisé en ce que** l'élément de réglage (22) a une première zone de contact pour monter l'élément de réglage (22) sur la pièce d'extrémité inférieure (24) de l'actionneur piézoélectrique (18), une zone de sertissage (30, 32) plastiquement déformable, dont la compression radiale provoque un allongement axial de l'élément de réglage (22) et une seconde zone de contact (34) pour entrer en contact avec la tête (26) du pointeau (20) de soupape.
4. Dispositif de dosage selon la revendication 3, **caractérisé en ce que** la première zone de contact de l'élément de réglage (22) et la pièce d'extrémité inférieure (24) de l'actionneur piézoélectrique (18)

comprennent des moyens de mise en prise (38, 39) correspondants pour monter l'élément de réglage (22) sur l'actionneur piézoélectrique (18).

5. Dispositif de dosage selon la revendication 3, **caractérisé en ce que** la seconde zone de contact de l'élément de réglage (22) comprend une broche à tête hémisphérique (34) trempée pour fournir un bon contact avec la tête (26) du pointeau.
6. Dispositif de dosage selon l'une quelconque des revendications précédentes, **caractérisé en ce que** l'élément de réglage (22) est formé comme un corps creux (30) tronconique et biconique avec une zone cylindrique centrale (32).
7. Dispositif de dosage selon l'une quelconque des revendications précédentes, **caractérisé en ce que** deux trous débouchants (28, 29) ou plus sont prévus dans le boîtier (12) du dispositif de dosage (10), alignés radialement avec une zone de sertissage (30, 32) de l'élément de réglage (22), les trous débouchants (28, 29) fournissant l'accès à l'élément de réglage (22) et permettant sa déformation plastique après l'assemblage complet du dispositif de dosage.
8. Procédé permettant de régler un débit d'un dispositif de dosage selon l'une quelconque des revendications précédentes, dans lequel le débit passant par le dispositif de dosage complètement assemblé est mesuré de manière répétée et l'élément de réglage est progressivement comprimé de manière radiale jusqu'à ce qu'un débit prédéterminé passant par le dispositif de dosage est obtenu.
9. Procédé selon la revendication 8, **caractérisé en ce qu'**afin de comprimer radialement l'élément de réglage, un ou plusieurs poinçons sont insérés dans les trous débouchants du boîtier et entraînés vers l'intérieur, induisant ainsi un réglage axial de l'espacement situé entre l'actionneur piézoélectrique et le pointeau de soupape.
10. Procédé selon la revendication 9, **caractérisé en ce que** le poinçon ou les poinçons sont entraînés vers l'intérieur par des courses imposées.
11. Procédé selon la revendication 9, **caractérisé en ce que** le poinçon ou les poinçons sont entraînés vers l'intérieur par une charge imposée.

FIG 1

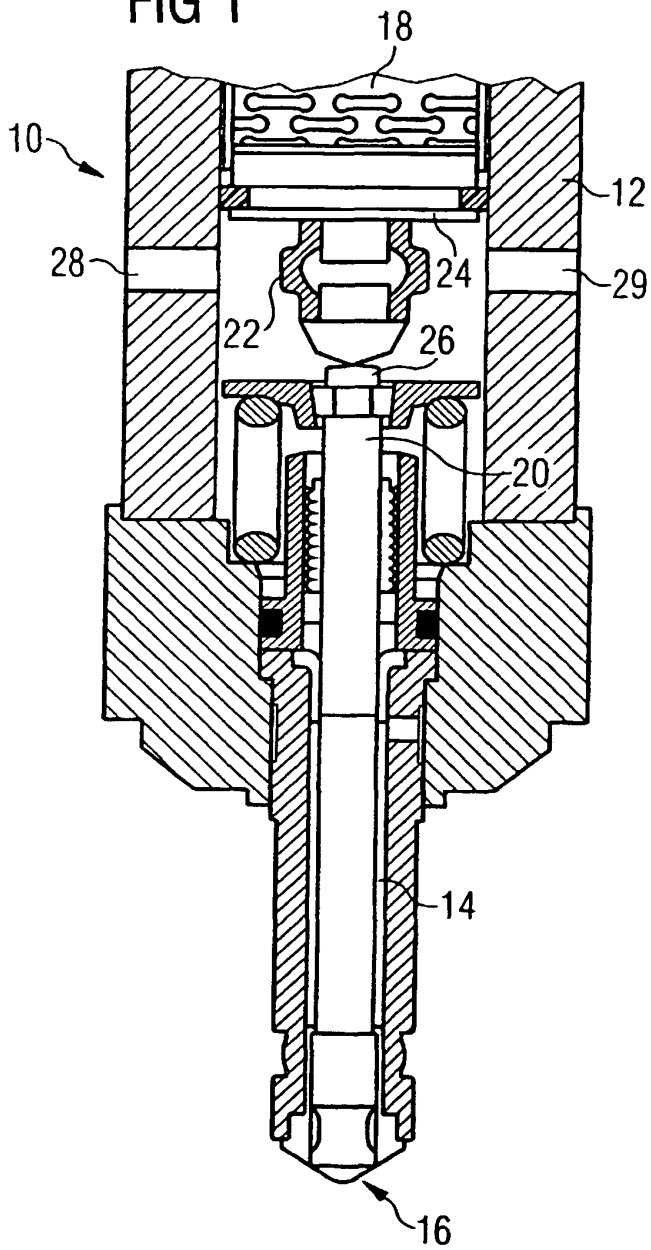


FIG 3

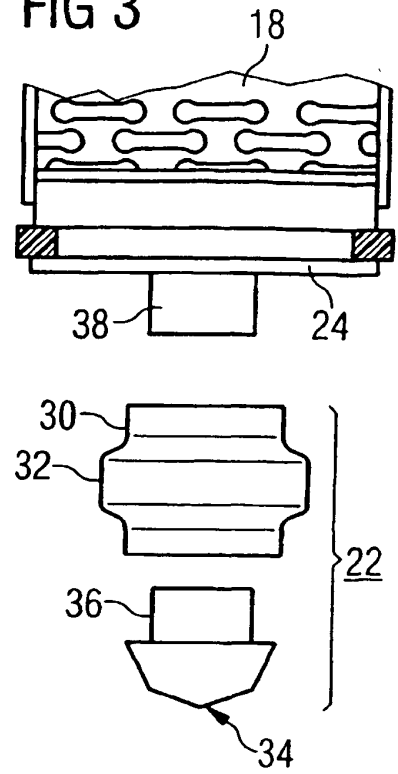


FIG 2

