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(54) **Injector for injecting fluid**

Injektor zum Einspritzen von Fluid

Injecteur pour injecter un fluide

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(73) Proprietor: **Continental Automotive GmbH**
30165 Hannover (DE)

(72) Inventors:
• **Agresta, Antonio**
56122 Pisa (IT)
• **Gestri, Luca**
56023 S. Lorenzo alle Corti (PI) (IT)

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Description

[0001] The invention relates to an injector for injecting fluid and relates particularly to an injector for injecting fuel into an internal combustion.

[0002] In a stratified operation mode, spray targeting performance is fundamental for a mixture preparation in a spark plug area. However, cavitation may occur in a nozzle of an injector. This may lead to fluctuations of a spray cone angle and/or a spray front angle. Further, deposits of combustion residues on the injector may distort a spray pattern. Engine misfire and increase of emissions may occur as a consequence.

[0003] The object of the invention is to provide an injector for injecting fluid with a reliable spray pattern.

[0004] This object is achieved with the features of the independent claim. Preferred embodiments are characterized in the dependent claims.

[0005] According to a first aspect the invention is characterized by an injector for injecting fluid. The injector comprises a valve needle comprising at its downstream end a closing element. The closing element extends to an outer edge and has a rounded portion with respect to a cross-section of the closing element with a contact area upstream of the outer edge.

[0006] The injector further comprises a cartridge comprising a seat cone, a recess, an outer surface and an upstream cone. The seat cone is arranged at a seat cone half angle with respect to a longitudinal axis of the cartridge. The seat cone forms a valve seat and extends to a downstream edge at a downstream end of the cartridge. In the recess the valve needle is arranged axially moveable. The outer surface is arranged directly adjacent to the downstream edge of the cartridge. The outer surface is on the same level with the outer edge of the closing element of the valve needle when the closing element is seated with its contact area on the valve seat of the cartridge. The upstream cone is arranged directly upstream of the seat cone and is arranged at an upstream cone half angle with respect to the longitudinal axis of the cartridge being smaller than the seat cone half angle of the seat cone and differing less than 15 degrees from the seat cone half angle.

[0007] The invention is based on the finding that a smooth acceleration of the fluid while streaming through the nozzle of the injector, which comprises a downstream portion of the cartridge with the seat cone and the upstream cone and the closing element of the valve needle, may reduce a risk of cavitation and by this of an undesirable variation of a spray cone angle and/or a spray front angle of a spray pattern of the injector. The invention is further based on the finding that by shortening a divergent length of the nozzle downstream the contact area of the closing element and the corresponding valve seat of the cartridge the risk of cavitation may be even further reduced. As a consequence, the spray pattern may be stabilized and may show an increased shot to shot repeatability. Further, an axial symmetry of the spray pat-

tern may be improved, particularly in case of very small amounts of fluid injected with each injection. The invention is further based on the finding that with the outer surface of the cartridge at its downstream end being on the same level with the outer edge of the closing element of the valve needle a risk of a build-up of deposits of combustion residues in a fluid path at a fluid outlet of the nozzle may be reduced and by that the spray pattern of the injector may also be stabilized. This particularly allows for a good long term stability of the spray pattern.

[0008] The closing element has a cone portion directly upstream the rounded portion arranged at a cone half angle with respect to the longitudinal axis of 50 to 60 degrees. The advantage is that a clear cross-section for the fluid flow may be particularly large and the fluid entering the nozzle from upstream the closing element may thus be even more smoothly accelerated while streaming through the nozzle. This further reduces the risk of cavitation and may thus improve the stability and repeatability of the spray pattern of the injector. Preferably, this cone half angle amounts to 58 degrees.

[0009] The seat cone half angle amounts to 40 to 50 degrees. This allows for a stable spray pattern. Preferably, this seat cone half angle amounts to 47.6 degrees.

[0010] The upstream cone half angle amounts to 28 to 38 degrees. This allows for a low risk of cavitation and by this allows for a stable spray pattern. Preferably, this upstream cone half angle amounts to 35 degrees.

[0011] According to a preferred embodiment, a gap between the outer edge of the closing element and the edge of the cartridge has a gap size of less than 2 micrometers when the closing element is seated with its contact area on the valve seat of the cartridge. The advantage is that by this a volume between the closing element and the cartridge at the fluid outlet of the nozzle may be very small and that as a consequence the build-up of deposits of combustion residues may be inhibited or at least reduced such that the spray pattern of the injector essentially is unaffected by deposits of combustion residues. This allows for a particularly good long term stability of the spray pattern.

[0012] According to a further preferred embodiment, the recess forms a cylindrical guiding surface for the valve needle. The cylindrical guiding surface is arranged directly upstream the upstream cone. The advantage is that the cartridge and, as a consequence, also the injector may be manufactured with few manufacturing steps and thus cost effective.

[0013] In the following, embodiments of the invention are illustrated with reference to the schematic drawings.

[0014] The figures are illustrating:

FIG. 1, an injector,

FIG. 2, a closing element of a valve needle,

FIG. 3, a first view of a downstream portion of a cartridge and the closing element,

FIG. 4, a second view of the downstream portion,

FIG. 5, a flow chart.

[0015] Elements of same construction or function are provided with the same reference signs throughout all figures. Primed reference signs 10', 11' and 14' correspond to features prior to a grinding operation explained below for step S4 in Figure 5 and corresponding reference signs 10, 11 and 14 correspond to features resulting from this grinding operation.

[0016] Figure 1 shows an injector for injecting a fluid. Particularly, the injector is designed for injecting fuel into a cylinder of an internal combustion engine of, for example, a vehicle and particularly an automobile. The injector comprises an external tube 1, an internal tube 2 and a valve cap 3. The fluid passes through an annular cavity between the external tube 1 and the internal tube 2 and through the valve cap 3. The injector further comprises a cartridge 4 with a recess 5 in which a valve needle 6 is arranged axially movable. The valve needle 6 comprises a closing element 7 at its downstream end arranged for closing the injector in its closed position inhibiting a fluid flow and for allowing the fluid flow otherwise. The injector further comprises a lifting device with an actuator 8 for moving the valve needle 6 in axial direction for opening and closing the injector. The actuator 8 preferably is a piezo actuator. However, the actuator 8 may alternatively be, for example, a solenoid actuator. In case of the actuator 8 being the piezo actuator, a lift generated by the lifting device depends on an axial elongation of the actuator 8 which is dependent on an electric control signal. The lifting device is mechanically coupled with the valve needle 6 and cooperates with the valve needle 6 such that at least part of the lift generated by the lifting device is transferred to the valve needle 6 moving the closing element 7 in its closed position or in an open position. Further, a closing force is provided to the valve needle 6 by a valve spring 9 which is preloaded during assembly of the injector. However, the injector may be designed differently.

[0017] Figure 2 shows the closing element 7 at the downstream end of the valve needle 6 and Figures 3 and 4 show a first and second view of a downstream portion of the cartridge 4 and the closing element 7, respectively. Figure 3 essentially shows part of a nozzle of the injector comprising the downstream portion of the cartridge 4 and the closing element 7.

[0018] The recess 5 of the cartridge 4 widens conically in the downstream portion of the cartridge 4 up to an edge 10, 10' of the cartridge 4 which represents a downstream end of the cartridge 4. A conical inner surface directly upstream the edge 10, 10' of the cartridge 4 forms a seat cone 18 of the cartridge 4 comprising a valve seat. The closing element 7 comprises a contact area 13 at a rounded portion 16 of the closing element 7. In the closed position of the closing element 7 the contact area 13 is sealingly seated on the valve seat inhibiting the fluid flow.

The contact area 13 at the rounded portion 16 allows for a ring-shaped contact line on the valve seat in the closed position of the closing element 7.

[0019] The closing element 7 widens downstream the contact area 13 up to an outer edge 14, 14' of the closing element 7. Prior to a grinding step for bringing an outer surface 11, 11' of the cartridge 4 and the outer edge 14, 14' of the closing element 7 to the same level, which is explained below, the closing element 7 comprises a first cone portion 15 directly upstream the outer edge 14, 14' and directly downstream the rounded portion 16 of the closing element 7. A seat cone half angle b_1 of the seat cone 18 of the cartridge 4 with respect to a longitudinal axis A of the cartridge 4, see step S1 in Figure 5, preferably is slightly larger than a first cone half angle a_1 of the first cone portion 15 of the closing element 7. By this, the seat cone 18 of the cartridge 4 and the first cone portion 15 of the closing element 7 diverge from the valve seat and contact area 13 in a direction of the fluid flow, that is, in downstream direction. Preferably, the angles differ by less than ten degrees and differ even more preferably by less than five degrees. The first cone half angle a_1 of the first cone portion 15 of the closing element 7 preferably amounts to about 46 degrees.

[0020] The closing element 7 further comprises a second cone portion 17 directly upstream the rounded portion 16 with a second cone half angle a_2 with respect to the longitudinal axis A of the cartridge 4. The second cone half angle a_2 preferably is greater than the first cone half angle a_1 and preferably amounts to 58 degrees. Due to this large second cone half angle a_2 the second cone portion 17 can be large and a clear cross-section for the fluid flow at an entrance of the nozzle can be large. By this, a risk of cavitation can be particularly low.

[0021] The cartridge 4 comprises directly upstream of the seat cone 18 an upstream cone 19 with an upstream cone half angle b_2 with respect to the longitudinal axis A of the cartridge 4, see step S1 in Figure 5. The upstream cone half angle b_2 is smaller than the seat cone half angle b_1 . The upstream cone half angle b_2 and the seat cone half angle b_1 differ by a cone half angle difference d of less than fifteen degrees. By this, a smooth transition is formed between the upstream cone 19 and the seat cone 18 allowing for a smooth change of the clear cross-section and thus for a smooth acceleration of the fluid while streaming through the nozzle. By this, the risk of cavitation can be particularly low.

[0022] Depending on a requested spray cone angle, the seat cone half angle b_1 ranges from 40 to 50 degrees. In this case, a nominal value of the first cone half angle a_1 is preferably about 1.5 degrees smaller than the seat cone half angle b_1 . The upstream cone half angle b_2 preferably is 12.6 degrees smaller than the seat cone half angle b_1 and the second cone half angle a_2 preferably is 10.4 degrees greater than the seat cone half angle b_1 . The seat cone half angle b_1 preferably amounts to 47.6 degrees and the upstream cone half angle b_2 preferably amounts to 35 degrees. These mentioned angle

differences preferably are kept constant over the mentioned range of the seat cone half angle b_1 of 40 to 50 degrees. The first cone half angle a_1 , the second cone half angle a_2 and the upstream cone half angle b_2 thus preferably are determined dependent on the choice of the seat cone half angle b_1 and the mentioned angle differences.

[0023] The recess 5 preferably forms a cylindrical guiding surface for the valve needle 6 and preferably is arranged directly upstream of the upstream cone 19. The recess 5, particularly at its downstream end, therefore preferably does not represent a wall of a fluid chamber with a diameter different from that of a guiding surface that may be arranged upstream of the fluid chamber. This has the advantage that the cylindrical guiding surface, the seat cone 18 and the upstream cone 19 can be manufactured in the same process step. By this, these can be manufactured very precise and a further step for manufacturing the fluid chamber is not necessary. The manufacturing can thus be efficient and cost effective.

[0024] Figure 5 shows a flow chart showing part of the manufacturing of the injector. The step S1 comprises providing the cartridge 4. The manufacturing of the cartridge 4 comprises grinding the recess 5, grinding the seat cone 18 with the seat cone half angle b_1 such that the seat cone 18 dilates in downstream direction up to the downstream end of the cartridge 4 and grinding the upstream cone 19 directly upstream the seat cone 18 with the upstream cone half angle b_2 being smaller with respect to the longitudinal axis A of the cartridge 4 than the seat cone half angle b_1 of the seat cone 18. The grinding of the recess 5, the seat cone 18 and the upstream cone 19 is preferably performed within the same grinding operation. The seat cone half angle b_1 and the upstream cone half angle b_2 differ by the cone half angle difference d of less than 15 degrees. The recess 5 preferably is ground to form the cylindrical guiding surface for the valve needle 6 such that the cylindrical guiding surface begins directly upstream the upstream cone 19 and extends in upstream direction far enough to allow for a precise and reliable guiding of the valve needle 6.

[0025] A step S2 comprises providing the valve needle 6 with the closing element 7. The closing element 7 comprises the first cone portion 15, the rounded portion 16 with the contact area 13 and preferably comprises also the second cone portion 17, the first cone portion 15 being arranged at the first cone half angle a_1 and the second cone portion 17 being arranged at the second cone half angle a_2 , see also Figure 2 for details. Step S2 further comprises determining a first length L of the first cone portion 15 between the outer edge 14' and the rounded portion 16.

[0026] A step S3 comprises arranging the valve needle 6 in the recess 5 of the cartridge 4 such that the closing element 7 sits with its contact area 13 on the valve seat of the cartridge 4. Generally, the outer surface 11' of the cartridge 4 directly adjacent to the edge 10' of the cartridge 4 at the downstream end of the cartridge 4 and the

outer edge 14' of the closing element 7 are not yet on the same level in this step. A step S4 therefore comprises grinding the outer surface 11' of the cartridge 4 and the closing element 7 from its outer edge 14' for a second length L' in upstream direction to the same level dependent on the first length L. Preferably, the second length L' equals the first length L. As a consequence, the first cone portion 15 essentially is completely ground away and the rounded portion 16 is arranged directly upstream the resulting outer edge 14 of the closing element 7. After grinding, the resulting outer edge 14 of the closing element 7 and the resulting outer surface 11 of the cartridge 4 preferably are on the same level. The result is shown in a step S5 and, in more detail, in Figures 3 and 4. The second length L' may alternatively be different from the first length L. However, limiting the grinding to the second length L' being smaller than or equal to the first length L has the advantage that the sealing between the valve seat of the cartridge 4 and the contact area 13 of the closing element 7 in its closed position is not affected by the grinding. With the second length L' being greater than the first length L there is a risk of destroying this sealing. However, dependent on the dimensions of the rounded portion 16 and the location of the contact area 13 the second length L' may also be selected to be greater than the first length L without the risk of destroying the sealing.

[0027] Due to the grinding in step S4 a volume of a gap between the seat cone 18 of the cartridge 4 and the rounded portion 16 downstream the contact area 13 and the corresponding valve seat can be very low, when the closing element 7 is seated with its contact area 13 on the valve seat of the cartridge 4. Preferably, a gap size G of the gap between the outer edge 14 of the closing element 7 and the edge 10 of the cartridge 4 amounts to about or preferably less than two micrometers.

Claims

1. Injector for injecting fluid, comprising

- a valve needle (6) comprising at its downstream end a closing element (7), the closing element (7) extending to an outer edge (14) and having a rounded portion (16) with respect to a cross-section of the closing element (7) with a contact area (13) upstream of the outer edge (14),
- a cartridge (4) comprising

- a seat cone (18) arranged at a seat cone half angle (b_1) with respect to a longitudinal axis (A) of the cartridge (4), the seat cone (18) forming a valve seat and extending to a downstream edge (10) at a downstream end of the cartridge (4),
- a recess (5) in which the valve needle (6) is arranged axially moveable,

-- an outer surface (11) directly adjacent to the edge (10) of the cartridge (4), the outer surface (11) being on the same level with the outer edge (14) of the closing element (7) of the valve needle (6) when the closing element (7) is seated with its contact area (13) on the valve seat of the cartridge (4) and

-- an upstream cone (19) arranged directly upstream of the seat cone (18) and arranged at an upstream cone half angle (b2) with respect to the longitudinal axis (A) of the cartridge (4) being smaller than the seat cone half angle (b1) of the seat cone (18) and differing less than 15 degrees from the seat cone half angle (b1),

characterized in that

the closing element (7) has a cone portion (17) directly upstream the rounded portion (16) arranged at a cone half angle (a2) with respect to the longitudinal axis (A) of 50 to 60 degrees,

that the seat cone half angle (b1) amounts to 40 to 50 degrees,

that the upstream cone half angle (b2) amounts to 28 to 38 degrees, and

that the seat cone half angle (b1) and the upstream cone half angle (b2) differ by a cone half angle difference of less than 15 degrees.

2. Injector according to claim 1, wherein a gap between the outer edge (14) of the closing element (7) and the edge (10) of the cartridge (4) has a gap size (G) of less than 2 micrometers when the closing element (7) is seated with its contact area (13) on the valve seat of the cartridge (4).
3. Injector according to any one of the preceding claims, wherein the recess (5) forms a cylindrical guiding surface for the valve needle (6), the cylindrical guiding surface being arranged directly upstream the upstream cone (19).

Patentansprüche

1. Injektor zum Einspritzen von Fluid, umfassend:
 - eine Ventalnadel (6) umfassend an ihrem abströmseitigen Ende ein Verschlusselement (7), wobei das Verschlusselement (7) sich zu einer äußeren Kante (14) erstreckt und einen in Bezug auf den Querschnitt des Verschlusselementes (7) abgerundeten Abschnitt mit einer Kontaktfläche (13) zuströmseitig von der äußeren Kante (14) aufweist,
 - eine Kartusche (4) umfassend
 - einen Sitzkegel (18), angeordnet mit ei-

nem Sitzkegel - Halbwinkel (b1) in Bezug auf die Längsachse (A) der Kartusche (4), wobei der Sitzkegel (18) einen Ventilsitz bildet und sich zu einer abströmseitigen Kante (10) an dem abströmseitigen Ende der Kartusche (4) erstreckt,

-- eine Ausnehmung (5), in welcher die Ventalnadel (6) axial beweglich angeordnet ist,

-- eine äußere Oberfläche (11), direkt angrenzend an die Kante (10) der Kartusche (4), wobei die äußere Oberfläche (11) sich auf dem gleichen Niveau mit der äußeren Kante (14) des Verschlusselementes (7) der Ventalnadel (6) befindet, wenn das Verschlusselement (7) mit seiner Kontaktfläche (13) auf dem Ventilsitz der Kartusche (4) sitzt und

-- einem Aufströmkegel (19), angeordnet direkt aufströmseitig von dem Sitzkegel (18) und angeordnet mit einem Aufströmkegel - Halbwinkel (b2) in Bezug auf die Längsachse (A) der Kartusche (4), der kleiner ist als der Sitzkegel - Halbwinkel (b1) des Sitzkegels (18) und sich weniger als 15 Grad von dem Sitzkegel - Halbwinkel (b1) unterscheidet,

dadurch gekennzeichnet dass

das Verschlusselement (7) einen Kegelabschnitt (17) direkt aufströmseitig von dem abgerundeten Abschnitt (16) aufweist, der mit einem Kegel - Halbwinkel (a2) in Bezug auf die Längsachse (A) von 50 bis 60 Grad angeordnet ist, dass sich der Sitzkegel - Halbwinkel (b1) auf 40 bis 50 Grad beläuft,

dass sich der Aufströmkegel - Halbwinkel (b2) auf 28 bis 38 Grad beläuft, und

dass sich der Sitzkegel - Halbwinkel (b1) und der Aufströmkegel - Halbwinkel (b2) um eine Kegelwinkeldifferenz von weniger als 15 Grad unterscheiden.

2. Injektor gemäß Anspruch 1, wobei der Spalt zwischen der äußeren Kante (14) des Verschlusselementes (7) und der Kante (10) der Kartusche (4) eine Spaltgröße (G) von weniger als 2 Mikrometer aufweist, wenn das Verschlusselement (7) mit seiner Kontaktfläche (13) auf dem Ventilsitz der Kartusche (4) sitzt.
3. Injektor gemäß irgendeinem der vorhergehenden Ansprüche, wobei die Ausnehmung (5) eine zylindrische Führungsfläche für die Ventalnadel (6) bildet, wobei die zylindrische Führungsfläche direkt aufströmseitig von dem Aufströmkegel (19) angeordnet ist.

Revendications

1. Injecteur destiné à l'injection d'un fluide, comprenant :

une aiguille d'injection (6) comprenant à son extrémité aval un élément de fermeture (7), l'élément de fermeture (7) s'étendant jusqu'à un bord externe (14) et ayant une portion arrondie (16) par rapport à une coupe transversale de l'élément de fermeture (7), avec une zone de contact (13) en amont du bord externe (14), une cartouche (4) comprenant :

un cône d'appui (18) aménagé sous un demi-angle de cône d'appui (b1) par rapport à un axe longitudinal (A) de la cartouche (4), le cône d'appui (18) formant un siège de soupape et s'étendant jusqu'à un bord aval (10) à une extrémité aval de la cartouche (4),

un évidement (5) dans lequel l'aiguille d'injection (6) est aménagée de façon à pouvoir se déplacer axialement,

une surface externe (11) directement adjacente au bord (10) de la cartouche (4), la surface externe (11) étant au même niveau que le bord externe (14) de l'élément de fermeture (7) de l'aiguille d'injection (6), lorsque l'élément de fermeture (7) est imbriqué avec sa zone de contact (13) sur le siège de soupape de la cartouche (4), et

un cône amont (19) aménagé directement en amont du cône d'appui (18) et aménagé sous un demi-angle de cône amont (b2) par rapport à l'axe longitudinal (A) de la cartouche (4), qui est inférieur au demi-angle de cône d'appui (b1) du cône d'appui (18) et différant de moins de 15 degrés du demi-angle de cône d'appui (b1), **caractérisé en ce que**

l'élément de fermeture (7) a une portion de cône (17) directement en amont de la portion arrondie (16) aménagée sous un demi-angle de cône (a2) par rapport à l'axe longitudinal (A) de 50 à 60 degrés,

le demi-angle de cône d'appui (b1) mesure de 40 à 50 degrés,

le demi-angle de cône amont (b2) mesure de 28 à 38 degrés, et

le demi-angle de cône d'appui (b1) et le demi-angle de cône amont (b2) diffèrent d'une différence de demi-angle de cône de moins de 15 degrés.

2. Injecteur selon la revendication 1, dans lequel un intervalle entre le bord externe (14) de l'élément de fermeture (7) et le bord (10) de la cartouche (4) a

une taille (G) inférieure à 2 micromètres lorsque l'élément de fermeture (7) est imbriqué avec sa zone de contact (13) sur le siège de soupape de la cartouche (4).

3. Injecteur selon l'une quelconque des revendications précédentes, dans lequel l'évidement (5) forme une surface de guidage cylindrique pour l'aiguille d'injection (6), la surface de guidage cylindrique étant aménagée directement en amont du cône amont (19).

FIG 1.

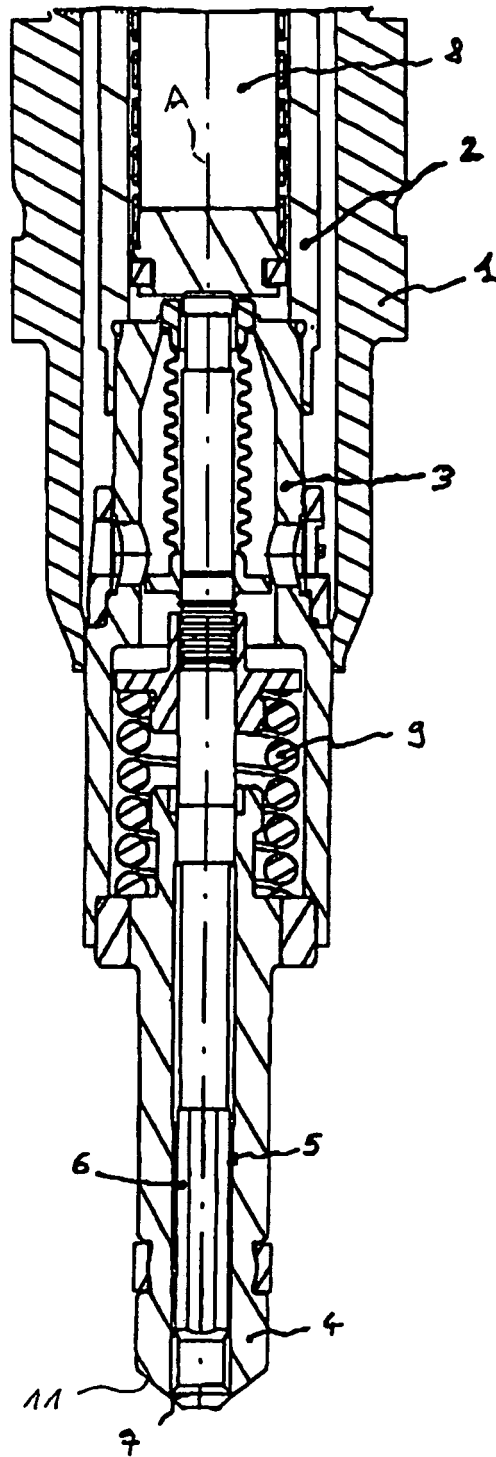


FIG 2

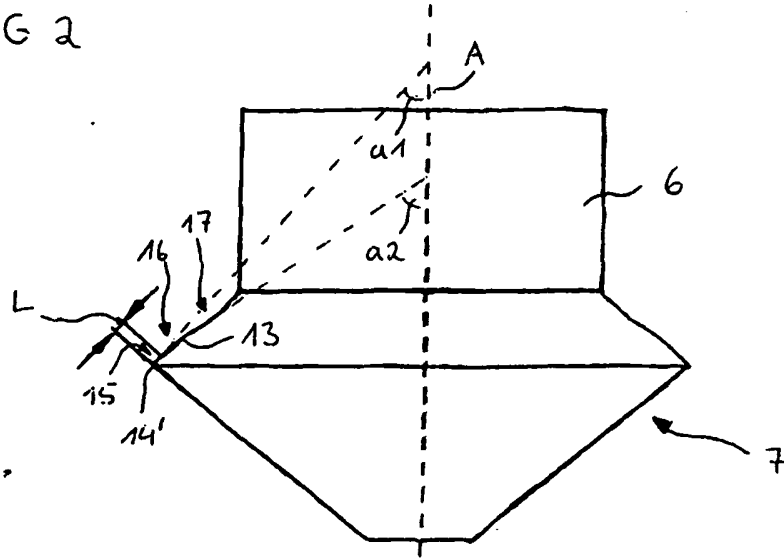


FIG 3

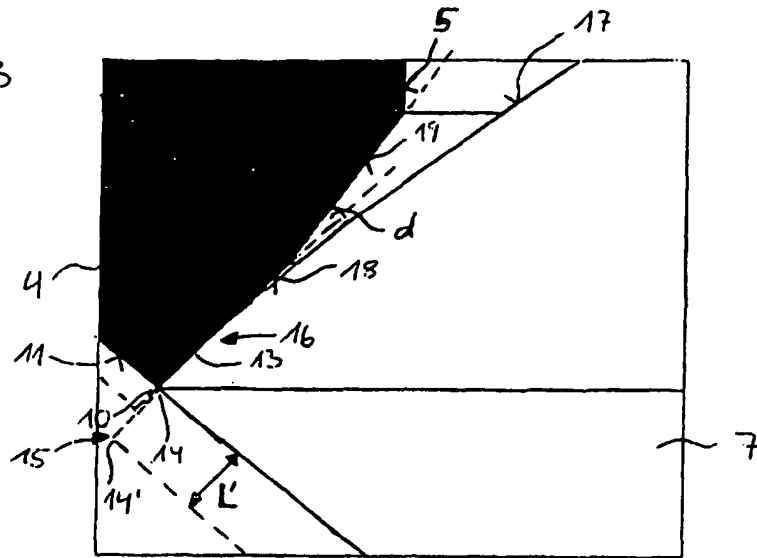


FIG 4

