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(54) Fuel injector of internal combustion engine

(57) To provide a fuel injector having a plurality of injection holes (112) injecting fuel into a combustion chamber of a gasoline engine in which each of the plurality of injection holes includes a guide section (114) to determine an injection direction and an injection amount of the fuel passing therethrough and a spreading section (116) to change a state of the fuel passing through the guide section to a spray state, and at least one of the plurality of injection holes is configured such that a central axis (118b) of the spreading section is parallel to a central axis (118a) of the guide section while being formed eccentrically on a side farther from a central axis (120) of the fuel injector than the central axis of the guide section.

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Description

[0001] The present invention relates to a fuel injector of an internal combustion engine.

[0002] A general fuel injector for a gasoline engine has a plurality of injection holes. A distance (penetration) which is a length from the injection point of a spray injected into a combustion chamber to an arrival point thereof within a predetermined period is affected by a momentum of the spray injected from each of the injection holes. Since momenta of the sprays which are injected from the injection holes having the same diameter are the same, the penetration of each spray is the same. Generally, it is considered that, if a diameter of the injection hole is increased, a flow rate of the fuel spray is increased. Therefore, the momentum of the spray is increased, whereby the penetration thereof is considered to be increased. Also, it is considered that, if a length of the injection hole is increased, the linearity of fuel is improved. Therefore, the air amount to be entrained into the spray which has been injected from the injection hole is reduced, whereby the spray is hardly decelerated by the air. As a result, the penetration thereof is considered to be increased. Thus, injection hole diameters of a plurality of injection holes formed on a fuel injector are not necessarily the same in order to optimize a state of a spray injected into a combustion chamber.

[0003] As a related art disclosure of a publication which relates to a shape and an arrangement method of a spreading section of an injection hole for preventing a spray from being obstructed, JP-A-08-312500 discloses a technique for a valve-closed-orifice (VCO) type fuel injector in which an outer peripheral surface of a small-diameter end portion of a truncated-conical-shaped seat portion of a needle valve of the VCO type injector is chamfered and a chamfered portion faces an opening end of an injection hole in a seat surface of a nozzle body at the time of fully lifting the needle valve in order to prevent variations in an injection amount of fuel injected from a plurality of injection holes and enhance uniformity of a spray formed by each injection hole so as to achieve improved exhaust emission properties and reduced operating noise, for example. Furthermore, a needle valve inner passage opened to the small-diameter end portion of the seat portion is provided in the needle valve and the needle valve inner passage is communicated with a fuel storage in the nozzle body at the time of lifting the needle valve.

[0004] Furthermore, in order to stabilize atomization and the injection direction of fuel by constituting nozzle holes of a nozzle plate to have diametrally equal hole portions and diametrally expanded hole portions, JP-A-2001-214839 discloses a technique in which the nozzle plate 15 is installed in a valve casing of the fuel injector so as to be positioned on a tip side of a valve seat member. In this case, nozzle holes 16 and 17 are respectively composed of the diametrally equal hole portions 16A and 17A linearly extended with an equal hole diameter d and the diametrally expanded hole portions 16B and 17B formed by expanding a diameter in a taper shape. Therefore, when injecting the fuel, an injection flow rate and the injection direction of the fuel are decided by the diametrally equal hole portions 16A and 17A to expand the jet to a specific area by the diametrally expanded portions 16B and 17B. Thereby, the fuel is held in an atomized state while directionality of injection fuel is stabilized.

[0005] In addition, in order to improve the combustion performance of an internal combustion engine during stratified charge combustion, JP-A-2004-232583 discloses a technique in which fuel is injected asymmetrically by increasing a fuel injection amount more to an intake side of a piston cavity than to an exhaust side (closer side to a spark plug). The fuel is received by a piston by the action of tumble streaming motion, then being curled upward in a combustion chamber. Even when the fuel is mixed and spreads more in the intake side than in the exhaust side, a homogenous stratified air-fuel mixture which is equal in concentration both in the intake and exhaust sides can be formed without becoming lean in the intake side or excessively thick in the exhaust side. Therefore, combustion is stabilized, and fuel consumption and exhaust gas purification performance are improved.

[0006] Still further, in order to form a spray which can exhibit good performance in both homogenous combustion and stratified charge combustion, in a fuel injector, JP-A-2007-132231 discloses a technique in which the fuel injector includes a injection hole group 230 of a plurality of injection holes for injecting fuel. In upstream of the injection hole group, a valve seat, a valve body for opening or closing a clearance between the valve body and the valve seat to open or close a fuel passage, and drive means for driving the valve body are provided. The injection hole group 230 has a plurality of injection holes 211 to 216 perforated to be different in angles of directions of axes of the holes, and a plurality of injection hole pairs made by combining these injection holes. The plurality of injection hole pairs have a first combination 230a in which an angle between the axes of the injection holes is large, and a second combination 230b in which an angle between the axes of the injection holes is smaller than that of the first combination 230a.

[0007] Meanwhile, in a general direct fuel-injection type gasoline engine, a fuel injector (injector) to inject fuel into a combustion chamber is mounted on a side surface of a cylinder in a state of being inclined with respect to a central axis of the cylinder (side-mount type). Furthermore, the fuel injector is provided with a plurality of injection holes on a tip thereof. In addition, an aperture angle of each injection hole of the fuel injector is determined such that a fuel spray injected from the injection hole generates an optimal air-fuel mixture in the combustion chamber. A homogenous combustion mode to generate an air-fuel mixture nearly homogenous in the combustion chamber or a stratified charge combustion mode in which the fuel spray is concentrated near a spark plug to secure an ignition performance and a comparatively lean air-fuel mixture is spread over the combustion chamber is exemplified. In other words, an aperture angle of each injection hole is not necessarily symmetric with respect to a central axis of the fuel injector, in response to various combustion states.

[0008] The description will be followed with reference to drawings. Fig. 1 is a longitudinal cross-sectional view of an intake two-valve type gasoline engine 1 mounted with a fuel injector 10 which shows an example of principal parts of the engine when injecting fuel during an intake process.

[0009] Fig. 1 shows an example of the intake two-valve type gasoline engine 1 adopting a side-mount type fuel injector 10. The gasoline engine 1 is provided with a intake valve 16 on an intake manifold 14 side of a cylinder head 12, a spark plug 18 in a central portion thereof and an exhaust valve 20 on an opposite side to the intake valve 16. The intake valve 16 and exhaust valve 20 are extended in a combustion chamber 22.

[0010] A piston 26 reciprocatively provided in a cylinder 24 of the gasoline engine 1 moves upward and downward in the cylinder 24, corresponding to the rotation of the crankshaft (not shown). The cylinder head 12 is installed in an upper portion of the cylinder 24 and forms a sealed space (combustion chamber 22) together with the cylinder 24. The cylinder head 12 is provided with the intake manifold 14 to introduce external air 30 into the combustion chamber 22 via an intake air quantity control device 28 equipped with a throttle valve (not shown) and an exhaust manifold 34 to introduce combustion gas 32 combusted in the combustion chamber 22 into an exhaust device (not shown).

[0011] The fuel injector 10 is installed near a joint portion of the intake manifold 14 of the cylinder head 12. In an example shown in Fig. 1, an axis line of the fuel injector 10 is set to be slightly downward in the combustion chamber 22.

[0012] In the gasoline engine 1 configured as above, a generation procedure of an air-fuel mixture in the combustion chamber 22 when fuel is injected into the combustion chamber 22 from the fuel injector 10 will be described. Fig. 2 is a schematic perspective view which shows an injection state of the air-fuel mixture in the combustion chamber 22 when injecting the fuel during the intake process, in the gasoline engine 1 shown in Fig. 1.

[0013] In the general fuel injector 10, if a plurality of injection holes (not shown in Fig. 2) provided in a tip (which is the injection point 30 in Fig. 2) thereof have the same diameter, momenta of the fuel spray 32 injected from each of the injection holes are the same. A distance (penetration) which is a length from the injection point of the spray 32 injected from the plurality of injection holes toward each area in the combustion chamber 22 to an arrival point thereof within a predetermined period is affected by the deceleration caused by contact with air in the combustion chamber 22 after the spray 32 is injected from the injection holes. Generally, it is considered that, if a injection hole diameter of the injection hole is increased, a flow rate of the spray 32 is increased. Therefore, the momentum of the spray 32 is increased, whereby the penetration thereof is increased. Also, it is considered that, if the injection hole length of the injection hole is increased, the linearity of fuel is improved. Therefore, the air amount to be entrained into the spray 32 which has been injected from the injection hole is reduced, whereby the spray 32 is hardly decelerated by the air. As a result, the penetration thereof is increased.

[0014] In order to generate an optimal air-fuel mixture in the combustion chamber 22 corresponding to various combustion states, the plurality of injection holes are provided in the tip of the fuel injector (not shown in Fig. 2). An angle of an axis of each injection hole is optimized such that the spray 32 is injected to be dispersed toward each area in the combustion chamber 22. As a result, some of the injection holes are not parallel to a central axis (not shown in Fig. 2) of the fuel injector, and also, an axis of each injection hole is not necessarily symmetric with respect to the central axis of the fuel injector.

[0015] Subsequently, the fuel injector 10 of the gasoline engine 1 described above will be described. Fig. 3 is a longitudinal cross-sectional view of the fuel injector 10 provided in the gasoline engine 1 shown in Fig. 1.

[0016] The fuel injector 10 is a normally-closed (NC) type solenoid valve. In the fuel injector 10, a ball-shaped tip portion 44 of the valve body 42 urged by a spring 40 is in close contact with a valve seat portion 48 (see Fig. 4) of a valve seat plate 46 such that the fuel supplied from a fuel supply opening 50 does not leak from an injection hole 52 (see Fig. 4). When current is conducted, the valve body 42 is displaced on a core 1056 side together with an anchor 1054, whereby a clearance is generated between the valve body 42 and the valve seat portion 48 (see Fig. 4) of the valve seat plate 46. The fuel is supplied from the fuel supply opening 50 and passes through a space next to the valve body 42 and an inflow groove 64 (see Fig. 5), then being injected, as a fuel spray, from a plurality of injection holes 52 (see Fig. 4) formed on the valve seat plate 46 in a perforated manner.

[0017] A fuel injection portion of the fuel injector 10 having a configuration described above will be described with reference to Figs. 4 to 6B. Fig. 4 is a longitudinal cross-sectional view enlarging a vicinity of the valve seat plate 46 in Fig. 3. Fig. 5 is a lateral cross-sectional view taken along a line V-V of Fig. 3. Figs. 6A and 6B are longitudinal cross-sectional views for describing the minimum thickness of the valve seat plate 46 in Fig. 3. A bored portion of the valve seat plate 46 has a dome shape matched to the ball-shaped tip portion 44 of the valve body 42 (see Fig. 3). Furthermore, in an inner surface of the valve seat plate 46, the valve seat portion 48 is formed at a portion on which the tip portion 44 abuts. A seal is formed when the tip portion 44 abuts on the valve seat portion 48. In addition, a sack portion 60 is formed in an inner-side tip of the valve seat plate 46. The sack portion 60 has a function to stabilize the injected spray when the tip portion 44 is separated from the valve seat portion 48 and therefore the fuel is injected by the fuel injector 10 (see Fig. 3).

[0018] Fuel passes through the clearance and the inflow groove 64 (see Fig. 5) provided in the fuel injector 10 (see Fig. 3) and reaches the valve seat portion 48 of the valve seat plate 46. Then, the fuel passed through a narrow pass between the tip portion 44 of the valve body 42 and the valve seat portion 48 of the valve seat plate 46 is moved in a central axis 62 direction of the fuel injector 10 (see Fig. 3) and reaches the plurality of injection holes 52 formed on the valve seat plate 46 in a perforated manner. Next, the fuel passes through the injection holes 52 and is injected into the combustion chamber 22 (see Fig. 2). The injection holes 52 are perforated to be different in angles of directions of axes thereof.

[0019] A guide section 54 which has a small diameter and is formed on an inflow side and a spreading section 56 which is a counter bore having a diameter greater than that of the guide section 54 and formed on an injection side constitute the injection hole 52 of the fuel injector 10, as shown in Fig. 4. A step portion perpendicular to a central axis 58 of the guide section 54 is formed on a bottom surface of the spreading section 56, for example. The fuel jet flowing from the guide section 54 to the combustion chamber 22 (see Fig. 2) via the spreading section 56 forms a fuel spray and spreads, as shown in Fig. 2.

[0020] The fuel which is passed through the narrow pass between the tip portion 44 of the valve body 42 and the valve seat portion 48 of the valve seat plate 46 and reaches the injection holes 52 flows in a radial direction flowing from an outward direction to the central axis 62 direction of the fuel injector 10 (see Fig. 3). Therefore, in the guide section 54 of the injection hole 52, a part of fuel flow is separated from a wall surface in a portion away from the central axis 62 of the fuel injector 10 (see Fig. 3). As a result, turbulence in a flow field occurs in the guide section 54. For example, turbulence occurs at a position shown by a reference symbol A in Fig. 4. Also, it is observed that the fuel which flows from the guide section 54 to the spreading section 56 spreads not in a conical shape evenly around the central axis 58 of the guide section 54 but in a shape where a spray angle is greater in a side away from the central axis 62 of the fuel injector 10 (see Fig. 3) than in a side closer to the central axis 62, by the influence of the turbulence in a flow field.

[0021] The shortest distance between the fuel spray and an outlet end portion of the spreading section 56 is located on a side away from the central axis 62 of the fuel injector 10 (see Fig. 3). Therefore, there is a possibility that the wall surface may interfere with the flow of the fuel spray in the outlet end portion of the spreading section, in some cases.

[0022] On the other hand, in order to prevent the spray from being obstructed, it is considerable to enlarge the spreading section 56 symmetrically with respect to the central axis 58 by expanding a diameter of the counter bore. However, if the diameter of the counter bore is increased, there is a possibility that the minimum thickness of the valve seat plate 46 cannot be ensured. For example, there is a possibility that the minimum thickness of a member allowed in the design of the valve seat plate 46 cannot be ensured around the location between the bottom surface of the spreading section 56 and the sack portion 60 of the valve seat plate 46 shown by a reference symbol B in Fig. 4. The minimum thickness required to withstand the pressure difference which is generated between inner and outer sides of the member when the fuel injector is used is exemplified as the minimum thickness of a member allowed in the design. If the spreading section (counter bore) 56 is bored shallowly in order to ensure the minimum thickness of a member, the fuel flows through the lengthy guide section 54 having a small diameter. Therefore, the linearity of the fuel jet is improved, whereby the deterioration of atomization performance and/or the increase of spray penetration may be caused at the spreading section 56. As a result, there is a possibility that a fuel spray may not be generated satisfactorily.

[0023] The description thereof will be followed in detail with reference to Figs. 6A and 6B. A case of the valve seat plate 46 formed with the sack portion 60 is shown in Fig. 6A, and a case of the valve seat plate 46 not formed with the sack portion 60 is shown in Fig. 6B. The minimum thickness portions (which are L_1 to L_3 in Fig. 6A and L_4 to L_6 in Fig. 6B) are formed between a corner of a bottom portion of the spreading section 56 and the sack portion 60. When the shape of the injection hole 52 corresponding to L_1 of Fig. 6A or L_4 of Fig. 6B is designated as a reference, if the diameter of the counter bore of the spreading section 56 is increased with respect to L_1 (L_4) so as to prevent the wall from interfering with the spray in the outlet end portion of the spreading section, the minimum thickness portion is formed at a location of L_2 (L_5). L_1 (L_4) is smaller than L_2 (L_5). In other words, if the diameter of the counter bore is increased, there is a possibility that the thickness of L_2 (L_5) may be smaller than the minimum thickness allowed in the design. If the guide section 54 is lengthened with respect to L_1 (L_4) and the diameter of the counter bore of the spreading section 56 is increased, the minimum thickness portion is formed at a location of L_3 (L_6). In this case, it is possible to make L_3 (L_6) have a thickness equal to or more than that of L_1 (L_4). However, the linearity of the fuel jet is improved due to the extension of the guide section 54, whereby the deterioration of atomization performance and/or the increase of spray penetration may be caused. As a result, there is a possibility that a fuel spray may not be generated satisfactorily.

[0024] Furthermore, Figs. 6A and 6B are views describing the case where cross-sectional surfaces including line segments (Note: the location having the minimum thickness is shown as a 'line segment' in the three-dimensional space), which show locations having the minimum thickness, are coincidentally on the same plane for convenience, in various shapes of the injection holes.

However, the only difference between the case described above and the case where the cross-sectional surfaces including the line segments, which show locations having the minimum thickness, are not on the same plane for each shape of the injection holes is that the description thereof cannot be illustrated on the same single view. Accordingly, the considerable point in this case is the same with the case where the line segments in various shapes of the injection holes are coincidentally on the same plane.

[0025] The present invention has been made to solve the problem described above. An object thereof is to provide a shape and an arrangement method of a spreading section of injection holes that prevent a spray from being obstructed by ensuring a short length of a guide section and the minimum thickness of a valve seat plate.

[0026] Hereinafter, means for solving the problem will be described. In addition, reference symbols in the accompanying drawings are noted in parentheses in order to facilitate the understanding of the present invention. However, the gist of the present invention is not limited to the embodiments shown in the drawings.

[0027] In order to solve the problem described above, there is provided a fuel injector (10) according to a first aspect of the invention that has a plurality of injection holes (112 or 212) injecting fuel into a combustion chamber (22) of an internal combustion engine (1), in which each of the plurality of injection holes includes a guide section (114, 144, 174 or 214) to determine an injection direction and an injection amount of the fuel passing therethrough and a spreading section (116, 146, 176 or 216) to change a state of the fuel passing through the guide section to a spray state, and at least one of the plurality of injection holes is configured such that a central axis (118b, 148b, 178b or 218b) of the spreading section is parallel to a central axis (118a, 148a, 178a or 218a) of the guide section while being formed eccentrically on a side farther from a central axis (120, 150, 180 or 220) of the fuel injector than the central axis of the guide section.

[0028] In the fuel injector, it is preferable that a counter bore is additionally formed on an outlet end of the spreading section in the injection hole. In this case, it is possible to ensure the minimum thickness of a valve seat plate and to prevent a wall surface from interfering with the spray injected from the spreading section in an outlet end portion.

[0029] Furthermore, it is preferable that the spreading section has a circular, oblong or elliptical shape seen from a fuel injection direction. In this case, it is possible for the spreading section to have various shapes to prevent the wall surface from interfering with the injected spray in the outlet end portion of the spreading section.

[0030] In order to solve the problem described above, there is provided a fuel injector (10) according to a second aspect of the invention that has a plurality of injection holes (312, 342, 412 or 442) injecting fuel into a combustion chamber (22) of an internal combustion engine (1), in which each of the plurality of injection holes includes a guide section (314, 344, 414 or 444) to determine an injection direction and an injection amount of the fuel passing therethrough and a spreading section (316, 346, 416 or 446) to change a state of the fuel passing through the guide section to a spray state, and, in at least one of the plurality of injection holes, the spreading section is configured such that a central axis (318b, 348b, 418b or 448b) of the spreading section is not parallel to a central axis (318a, 348a, 418a or 448a) of the guide section, and at least some of points on a line segment, which is a part of the central axis of the spreading section disposed in the spreading section, are located at a position farther from a central axis (320, 350, 420 or 450) of the fuel injector than any point on a line segment, which is a part of an extension line of the central axis of the guide section disposed in the spreading section or a valve seat plate.

[0031] In the fuel injector, it is preferable that a counter bore is additionally formed on an outlet end of the spreading section in the injection hole. In this case, it is possible to ensure the minimum thickness of a valve seat plate and to prevent a wall surface from interfering with the spray injected from the spreading section in an outlet end portion.

[0032] In order to solve the problem described above, there is provided a fuel injector (10) according to a third aspect of the invention that has a plurality of injection holes injecting fuel into a combustion chamber (22) of an internal combustion engine (1) and that has at least one injection hole (812) including a guide section (814) to determine an injection direction and an injection amount of the fuel passing therethrough and a spreading section (816) to change a state of the fuel passing through the guide section to a spray state, in which, when the spreading section is divided into a first region away from the central axis of the fuel injector and a second region closer to the central axis thereof in a second plane (840) which is perpendicular to a first plane (830), which passes a central axis (820) of the fuel injector and passes through a center of an outlet of the guide section, and includes a central axis of the guide section, a distance (d_1) which is from a first farthest point (P) farthest away from the second plane of the first region to the second plane is greater than a distance (d_2) which is from a second farthest point (Q) farthest away from the second plane of the second region to the second plane, in a third plane (850) which passes through a shallowest portion of an outlet end of the spreading section and is parallel to a bottom surface of the spreading section, or a volume (V_1) on the first region side is greater than a volume (V_2) on the second region side in a region surrounded by the third plane and the bottom surface of the spreading section.

[0033] According to adopting a configuration of the present invention, it is possible to secure the thickness of a valve seat plate while preventing obstruction with a spray spread outside and reducing a counter bore on an inner side where the spray is relatively spread in small amount.

[0034] It is possible to prevent an injection hole length from increasing by only carrying out limitation for securing the thickness of a member.

Fig. 1 is a longitudinal cross-sectional view of an intake two-valve type gasoline engine mounted with a fuel injector which shows an example of principal parts of the engine when injecting fuel during an intake process.
Fig. 2 is a schematic perspective view which shows a state of an air-fuel mixture in a combustion chamber when injecting the fuel during the intake process, in the gasoline engine shown in Fig. 1.
Fig. 3 is a longitudinal cross-sectional view of the fuel injector provided in the gasoline engine shown in Fig. 1.
Fig. 4 is a longitudinal cross-sectional view enlarging the vicinity of a valve seat plate of Fig. 3.
Fig. 5 is a lateral cross-sectional view taken along a line V-V of Fig. 3.
Figs. 6A and 6B are longitudinal cross-sectional views for describing the minimum thickness of the valve seat plate in Fig. 3.
Figs. 7A to 7C are longitudinal cross-sectional views of a valve seat plate having a parallel-eccentric type injection hole.
Fig. 8 is a longitudinal cross-sectional view of a valve seat plate having an oblong type injection hole.
Figs. 9A and 9B are cross-sectional views of a valve seat plate having a non-parallel type injection hole.
Fig. 10 is a longitudinal cross-sectional view describing a position of a cross-sectional surface of the valve seat plate shown in Figs. 9A and 9B.
Fig. 11 is a longitudinal cross-sectional view of the valve seat plate having a non-parallel type injection hole.
Fig. 12 is a longitudinal cross-sectional view of a valve seat plate having an injection hole according to a modification example of an embodiment shown in Fig. 11.
Figs. 13A to 13C are longitudinal cross-sectional views of valve seat plates having injection holes formed with counter bores on outlet sides of spreading sections.
Figs. 14A to 14C are views describing a shape of an injection hole with respect to a central axis of a valve seat plate.
Figs. 15A and 15B are cross-sectional views describing a shape of an injection hole with respect to a central axis of a valve seat plate.

[0035] Embodiments of the present invention will be described with reference to drawings.

Parallel-eccentric Type

[0036] Figs. 7A to 7C are longitudinal cross-sectional views of a valve seat plate 110 having a parallel-eccentric type injection hole 112. A sack portion 122 to stabilize a spray is formed in an inner-side tip of the valve seat plate 110.

[0037] In Fig. 7A, a guide section 114 which has a small diameter and is formed on an inflow side and a spreading section 116 which has a diameter greater than that of the guide section 114 and is formed on an injection side constitute the injection hole 112 of the valve seat plate 110. A central axis 118a of the guide section 114 is parallel to a central axis 120 of the fuel injector 10 (see Fig. 3), and a central axis 118b of the spreading section 116 is parallel to the central axis 118a of the guide section 114. In addition, the central axis 118b of the spreading section 116 is formed eccentrically on a side away from the central axis 120 of the fuel injector 10 (see Fig. 3), with respect to the central axis 118a of the guide section 114. A step portion perpendicular to the central axis 118a of the guide section 114 is formed on a bottom surface of the spreading section 116, for example. The fuel jet flowing from the guide section 114 to a combustion chamber 22 (see Fig. 2) via the spreading section 116 forms a fuel spray and spreads.

[0038] According to the configuration described above, since the length of the guide section 114 is not increased, the penetration of the spray is not changed. Therefore, the minimum thickness of the valve seat plate 110 can be ensured in the vicinity between a bottom surface of the spreading section 116 and the sack portion 122 of the valve seat plate 110. Also, it is possible to prevent a wall surface from interfering with the spray injected from the spreading section 116 in an outlet end portion of the spreading section 116.

Modification Example 1 of Parallel-eccentric Type

[0039] Further, a modification example 1 in which the central axis 148b of the spreading section 146 is parallel to a central axis 148a of a guide section 144, and the central axis 148a of the guide section 144 is inclined in a direction narrowing in a fuel injection direction with respect to a central axis 150 of the fuel injector 10 (see Fig. 3) is also conceivable (see Fig. 7B). In this case, since the length of the guide section 144 is not increased either, the penetration of the spray is not changed. In addition, the central axis 148b of the spreading section 146 parallel to the central axis 148a of the guide section 144 is formed eccentrically on a side away from the central axis 150 of the fuel injector 10 (see Fig. 3), with respect to the central axis 148a of the guide section 144, whereby it is possible to prevent a wall surface from interfering with the spray injected from the spreading section 146 in an outlet end portion of the spreading section 146.

Modification Example 2 of Parallel-eccentric Type

[0040] Still further, a central axis 178a of a guide section 174 and a central axis 178b of a spreading section 176 parallel to a central axis 178a may be inclined in a direction widening with respect to a central axis 180 of the fuel injector 10 (see Fig. 3) (see Fig. 7C). The point is that the fuel injector 10 may have a configuration in which the obstruction between the spray injected from the spreading section 176 and a wall surface is prevented in an outlet end portion of the spreading section 176 by setting the central axis 178b of the spreading section 176 to be eccentric with respect to the central axis 178a of the guide section 174 without increasing the length of the guide section 174.

Oblong Type

[0041] Fig. 8 is a longitudinal cross-sectional view of a valve seat plate 210 having an oblong type injection hole 212. In the embodiment, a guide section 214 having a small diameter and a spreading section 216 having an oblong shape (rectangle with rounded corner) big enough to include the guide section 214 constitute the injection hole 212. A central axis 218a of the guide section 214 is parallel to a central axis 220 of the fuel injector 10 (see Fig. 3), and a central axis 218b of the spreading section 216 is parallel to the central axis 218a of the guide section 214. In addition, the central axis 218b of the spreading section 216 is formed eccentrically on a side away from the central axis 220 of the fuel injector 10 (see Fig. 3), with respect to the central axis 218a of the guide section 214. For example, it is considerable to match an axis of a semicircle in the oblong-shaped spreading section 216 with the central axis 218a of the guide section 214.

[0042] According to this configuration, since the length of the guide section 214 is not increased, the penetration of the spray is not changed. Therefore, the minimum thickness of the valve seat plate 210 can be ensured in the vicinity between a bottom surface of the spreading section 216 and a sack portion 222 of the valve seat plate 210. Also, it is possible to prevent a wall surface from interfering with the spray injected from the spreading section 216 in an outlet end portion of the spreading section 216.

Modification Examples 1 and 2 of Oblong Type

[0043] Further, the same effect can be obtained in a modification example of an oblong type (rectangle with rounded corner) where the length of the guide section 214 is not increased and the spreading section 216 has an elliptical shape (modification example 1) (not shown). In addition, it may be possible to adopt the configuration where the length of the guide section 214 is not increased and the central axis 218a of the guide section 214 is inclined with respect to the central axis 220 of the fuel injector 10 (see Fig. 3), as similar to the modification example of the eccentric type (modification example 2) (not shown).

Non-parallel Type

[0044] Next, a valve seat plate having a non-parallel type injection hole will be described with reference to Figs. 9A to 10. Figs. 9A and 9B are cross-sectional views of valve seat plates 310 and 340 having non-parallel type injection holes 312 and 342 respectively. Fig. 10 is a longitudinal cross-sectional view describing a position of a cross-sectional surface of the valve seat plates 310 and 340 shown in Figs. 9A and 9B. In Figs. 9A and 9B, the injection holes 312 and 342 are configured such that central axes 318b and 348b of spreading sections 316 and 346 are not parallel to central axes 318a and 348a of guide sections 314 and 344, and also, disposed on the same plane α. Also, the plane α is inclined with respect to central axes 320 and 350 of the fuel injector 10 (see Fig. 3), as shown in Fig. 10. In this case, the plane α of Fig. 10 shows the position of a cross-sectional surface shown in Figs. 9A and 9B. Therefore, the central axes 320 and 350 of the fuel injector 10 (see Fig. 3) shown in Figs. 9A and 9B are not on the cross-sectional surface shown in Figs. 9A and 9B. A portion on a lower side in the drawings is close to a sheet of paper. Also, as coming closer to an upper side in the drawings, a portion is gradually away from a sheet of paper.

[0045] As shown in Fig. 9A, a part of the central axis 318b of spreading section 316 which is disposed in the spreading section 316 is designated as a line segment S_1. In the central axis 318a of the guide section 314, "a line segment which is a part of the extension line of the central axis of the guide section and disposed in the spreading section" is designated as T_1, and "a line segment which is a part of the extension line of the central axis of the guide section and disposed in the valve seat plate" is designated as U_1. Furthermore, any of the central axis 318b of the spreading section 316 and the central axis 318a of the guide section 314 are inclined in a direction narrowing in the fuel injection direction. In Fig. 9A of the embodiment, the injection hole 312 is configured such that a portion (the lowest point of the line segment S_1) shown by a point C_1 on the line segment S_1 is disposed at a location farthest away from the central axis 320 of the fuel injector 10 (see Fig. 3), compared to any point on the line segments T_1 and U_1.

[0046] Upon comparison with the valve seat plate 310 shown in Fig. 9A, the valve seat plate 340 shown in Fig. 9B is different in that "a line segment which is a part of the extension line of the central axis of the guide section and disposed in the valve seat plate" (which is a part shown by U_1 in Fig. 9A) is not included. As shown in Fig. 9B, a part of the central axis 348b of the spreading section 346 which is disposed in the spreading section 346 is designated as a line segment S_2. Also, in the central axis 348a of the guide section 344, "a line segment which is a part of the extension line of the central axis of the guide section and disposed in the spreading section" is designated as T_2. Furthermore, any of the central axis 348b of the spreading section 346 and the central axis 348a of the guide section 344 are inclined in a direction narrowing in the fuel injection direction. In the embodiment, the injection hole 342 is configured such that a portion shown by a point C_2 on the line segment S_2 in Fig. 9B is disposed at a location farther away from the central axis 350 of the fuel injector 10 (see Fig. 3), compared to any point on the line segment T_2.

Modification Example 1 of Non-parallel Type

[0047] Fig. 11 is a longitudinal cross-sectional view of a valve seat plate 410 having a non-parallel type injection hole 412 according to a modification example 1 of the non-parallel type. Upon comparison with the embodiment shown in Figs. 9A and 9B where the plane α including both of the central axes 318b and 348b of the spreading sections 316 and 346 and the central axes 318a and 348a of the guide sections 314 and 344 is inclined with respect to the central axes 320 and 350 of the fuel injector 10 (see Fig. 3), the modification example 1 is different in that a plane including both of a central axis 418b of a spreading section 416 and a central axis 418a of a guide section 414 is parallel to a central axis 420 of the fuel injector 10 (see Fig. 3).

[0048] In the modification example 1 shown in Fig. 11, the guide section 414 having a small diameter and the spreading section 416 having a diameter greater than that of the guide section 414 constitutes the injection hole 412. The central axis 418a of the guide section 414 is parallel to the central axis 420 of the fuel injector 10 (see Fig. 3). On the other hand, the central axis 418b of the spreading section 416 passes through the center of an outlet of the guide section 414 and is inclined in a direction away from the central axis 420 of the fuel injector 10 (see Fig. 3) toward the fuel injection direction. As a result, the central axis 418b of the spreading section 416 is disposed so as not to be parallel to the central axis 418b of the spreading section 416 and the central axis 420 of the fuel injector 10 (see Fig. 3).

[0049] The central axis 418b of the spreading section 416 is disposed so as to be inclined in a direction away from the central axis 420 toward the fuel injection direction. The inclination angle of the central axis 418b is determined in consideration of the jet angle (see Fig. 4) of the spray injected from the spreading section 416. In the embodiment shown in Fig. 11, the inclination angle is determined such that the distances between the spray injected from the spreading section 416 and wall surfaces in an outlet end portion of the spreading section 416 are the same to a near side and a far side with regard to the central axis 420.

[0050] According to the configuration described above, since the length of the guide section 414 is not increased, the penetration of the spray is not changed. Therefore, the minimum thickness of the valve seat plate 410 can be ensured in the vicinity between a bottom surface of the spreading section 416 and a sack portion 422 of the valve seat plate 410. Also, it is possible to prevent a wall surface from interfering with the spray injected from the spreading section 416 in the outlet end portion of the spreading section 416.

Modification Example 2 of Non-parallel Type

[0051] Fig. 12 is a longitudinal cross-sectional view of a valve seat plate 440 having a non-parallel type injection hole 442 according to a modification example 2 of the non-parallel type. In the modification example 2, a central axis 448b of a spreading section 446 does not pass through the center of an outlet of a guide section 444. Also, the midpoint of the central axis 448b of the spreading section 446 is disposed at a location farther away from a central axis 450 of the fuel injector 10 (see Fig. 3) with respect to the center of the outlet of the guide section 444. According to the configuration described above, since the length of the guide section 444 is not increased, the penetration of the spray is not changed. Therefore, the minimum thickness of the valve seat plate 440 can be ensured in the vicinity between a bottom surface of the spreading section 446 and a sack portion 452 of the valve seat plate 440. Also, it is possible to prevent a wall surface from interfering with the spray injected from the spreading section 446 in an outlet end portion of the spreading section 446.

Modification Example 3 of Non-parallel Type

[0052] The embodiment shown in Figs. 9A and 8B shows the configuration where the central axes 318b and 348b of the spreading sections 316 and 346 are not parallel to the central axes 318a and 348a of the guide sections 314 and 344 while the central axes thereof are disposed on the same plane α. However, the present invention is not limited thereto and a configuration where, for example, the central axis of the spreading section is disposed at a position deviated from the central axis of the guide section may be adoptable (not shown).

Modification Example having Two-stage Spreading Section

[0053] Figs. 13A to 13C are longitudinal cross-sectional views of valve seat plates 510, 610 and 710 respectively having injection holes 512, 612 and 712 formed with counter bores 530, 630 and 730, which are coaxial to central axes of guide sections 514, 614 and 714, on outlet sides of spreading sections 516, 616 and 716. Fig. 13A shows an example where the counter bore 530 is formed on the valve seat plate 510 having the eccentric type injection hole 512 described in Figs. 7A to 7C. Fig. 13B shows an example where the counter bore 630 is formed on the valve seat plate 610 having the oblong type injection hole 612 described in Figs. 7A to 7C. Fig. 13C shows an example where the counter bore 730 is formed on the valve seat plate 710 having the non-parallel type injection hole 712 described in Figs. 7A to 7C.

In any examples, the minimum thickness of the valve seat plates 510, 610 and 710 can be ensured, and also, it is possible to prevent a wall surface from interfering with the spray injected from the spreading sections 516, 616 or 716 in an outlet end portion thereof. Furthermore, it is described that the counter bores additionally provided in the spreading sections are coaxial to the central axes of the guide sections, in the examples. However, it is also possible to set the counter bores to be coaxial to the spreading sections or to be coaxial to neither of them.

Shape of Injection Hole with Respect to Central Axis of Fuel Injector

[0054] Figs. 14A to 15B are views describing a shape of an injection hole 812 with respect to a central axis 820 of a valve seat plate 810 (that is, the fuel injector 10 (see Fig. 3)) according to the present invention. In Fig. 14A, a first plane 830 includes the central axis 820 of the valve seat plate 810 and passes through a center of an outlet of a guide section 814 (see Figs. 15A and 15B). A second plane 840 is perpendicular to the first plane 830 and includes a central axis 818a (see Figs. 15A and 15B) of the guide section 814 (see Figs. 15A and 15B). A fourth plane 860 is perpendicular to the second plane 840 and includes a central axis 818b (see Figs. 15A and 15B) of a spreading section 816 (see Figs. 15A and 15B). Fig. 14B is a view seen from a direction of an intersection line of the second plane 840 and the fourth plane 860. Fig. 14C is a perspective view showing a state where the valve seat plate 810 is cut in the fourth plane 860.

[0055] Fig. 15A is a cross-sectional view of the valve seat plate 810 in the fourth plane 860 (see Fig. 15B), and Fig. 15B is a view showing a positional relationship of the fourth plane 860 with regard to the central axis 820 of the fuel injector 10 (see Fig. 3). In Fig. 15A, the second plane 840 (see Figs. 14A to 14C) corresponds to a location of the central axis 818a of the guide section 814. A third plane 850 passes through a point P (described below) and is parallel to a bottom surface of the spreading section 816. Since the bottom surface of the spreading section 816 is perpendicular to the central axis of the spreading section 816, the third plane 850 is also perpendicular to the fourth plane 860. In the embodiment shown in Figs. 15A and 15B, the central axis 818a of the guide section 814 is disposed at a position deviated from the central axis 820 of the valve seat plate 810.

[0056] When the spreading section 816 is divided into a first region away from the central axis of the fuel injector and a second region closer to the central axis thereof in the second plane 840 (see Figs. 14A and 14C) (that is, a position of the axis 818a of the guide section 814 in Figs. 15A and 15B), a distance d_1 which is from the point P farthest away from the second plane 840 (see Figs. 14A to 14C) (that is, the axis 818a) of the first region to the second plane 840 (see Figs. 14A to 14C) (that is, the axis 818a in Figs. 15A and 15B) is greater than a distance d_2 which is from a point Q farthest away from the second plane 840 (see Figs. 14A to 14C) (that is, the axis 818a) of the second region to the second plane 840 (see Figs. 14A to 14C) by Δd (=d_1-d_2), in the third plane 850 which passes through the shallowest portion of an outlet end of the spreading section 816 and is parallel to the bottom surface of the spreading section 816. This description coincides with the embodiment described above where the central axis of the guide section is disposed at a position not deviated from the central axis of the valve seat plate.

[0057] Furthermore, in this case, a volume V_1 on the first region side is greater than a volume V_2 on the second region side in a region surrounded by the third plane 850 and the bottom surface of the spreading section 816. This description coincides with the embodiment described above where the central axis of the guide section is disposed at a position not deviated from the central axis of the valve seat plate, as well.

[0058] In addition, the present invention is applied to a side-mount type direct fuel-injection engine in the application examples described above. However, the present invention is not limited to the side-mount type and is applicable to other engine types such as a center-mount type.

[0059] According to adopting a configuration of the present invention, it is possible to secure the thickness of a valve seat plate while preventing obstruction with a spray spread outside and reducing a counter bore on an inner side where the spray is relatively spread in small amount.

[0060] It is possible to prevent an injection hole length from increasing by only carrying out limitation for securing the thickness of a member.

[0061] Consequently, the present invention has a remarkable industrial value.

Claims

1. A fuel injector (10) having a plurality of injection holes (112 or 212) injecting fuel into a combustion chamber (22) of an internal combustion engine (1), which is **characterized in that**
each of the plurality of injection holes includes a guide section (114, 144, 174 or 214) to determine an injection direction and an injection amount of the fuel passing therethrough and a spreading section (116, 146, 176 or 216) to change a state of the fuel passing through the guide section to a spray state, and
at least one of the plurality of injection holes is configured such that a central axis (118b, 148b, 178b or 218b) of the spreading section is parallel to a central axis (118a, 148a, 178a or 218a) of the guide section while being formed eccentrically on a side farther from a central axis (120, 150, 180 or 220) of the fuel injector than the central axis of the guide section.

2. The fuel injector according to Claim 1, which is **characterized by** further comprising:

a counter bore which is formed on an outlet end of the spreading section in the injection hole.

3. The fuel injector according to Claim 1, which is **characterized in that** the spreading section has a circular, oblong or elliptical shape seen from a fuel injection direction.

4. A fuel injector (10) having a plurality of injection holes (312, 342, 412 or 442) injecting fuel into a combustion chamber (22) of an internal combustion engine (1), which is **characterized in that** each of the plurality of injection holes includes a guide section (314, 344, 414 or 444) to determine an injection direction and an injection amount of the fuel passing therethrough and a spreading section (316, 346, 416 or 446) to change a state of the fuel passing through the guide section to a spray state, and in at least one of the plurality of injection holes, the spreading section is configured such that a central axis (318b, 348b, 418b or 448b) of the spreading section is not parallel to a central axis (318a, 348a, 418a or 448a) of the guide section, and at least some of points on a line segment, which is a part of the central axis of the spreading section disposed in the spreading section, are located at a position farther from a central axis (320, 350, 420 or 450) of the fuel injector than any point on a line segment, which is a part of an extension line of the central axis of the guide section disposed in the spreading section or a valve seat plate.

5. The fuel injector according to Claim 4, which is **characterized by** further comprising:

a counter bore which is formed on an outlet end of the spreading section in the injection hole.

6. A fuel injector (10) having a plurality of injection holes injecting fuel into a combustion chamber (22) of an internal combustion engine (1) that has at least one injection hole (812) including a guide section (814) to determine an injection direction and an injection amount of the fuel passing therethrough and a spreading section (816) to change a state of the fuel passing through the guide section to a spray state, which is **characterized in that** when the spreading section is divided into a first region away from the central axis of the fuel injector and a second region closer to the central axis thereof in a second plane (840) which is perpendicular to a first plane (830), which passes a central axis (820) of the fuel injector and passes through a center of an outlet of the guide section, and includes a central axis of the guide section, a distance (d_1) which is from a first farthest point (P) farthest away from the second plane of the first region to the second plane is greaPatent Attonerter than a distance (d_2) which is from a second farthest point (Q) farthest away from the second plane of the second region to the second plane, in a third plane (850) which passes through a shallowest portion of an outlet end of the spreading section and is parallel to a bottom surface of the spreading section, or
a volume (V_1) on the first region side is greater than a volume (V_2) on the second region side in a region surrounded by the third plane and the bottom surface of the spreading section.

Fig. 1

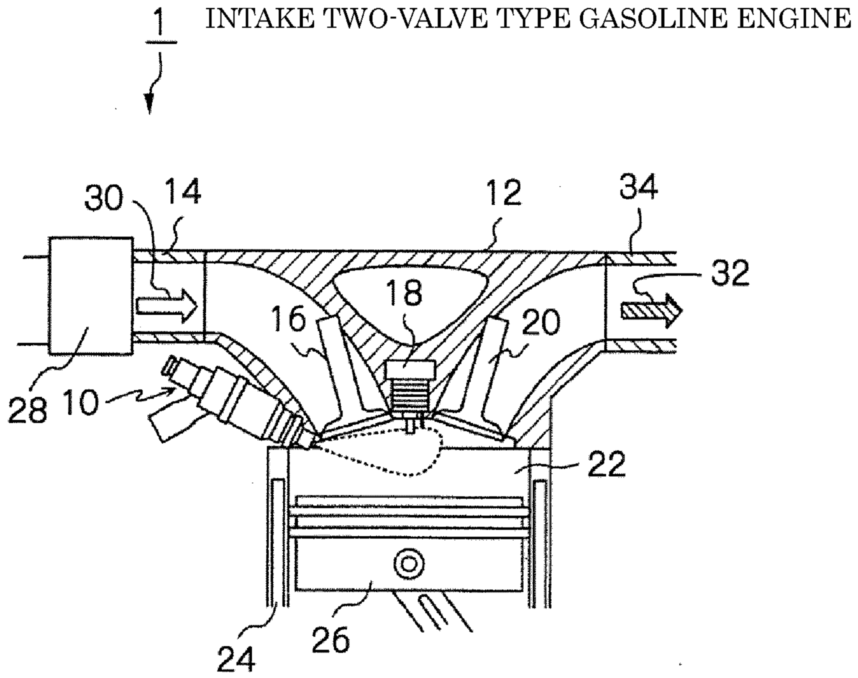

1
INTAKE TWO-VALVE TYPE GASOLINE ENGINE
30
14
12
34
32
18
16
20
28
10
22
24
26

Fig. 2

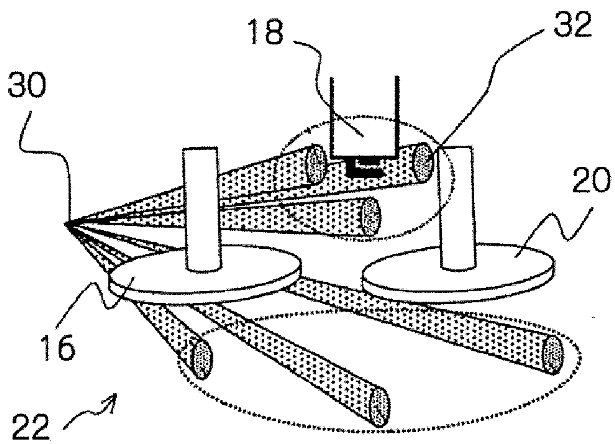

18
32
30
20
16
22

Fig. 3

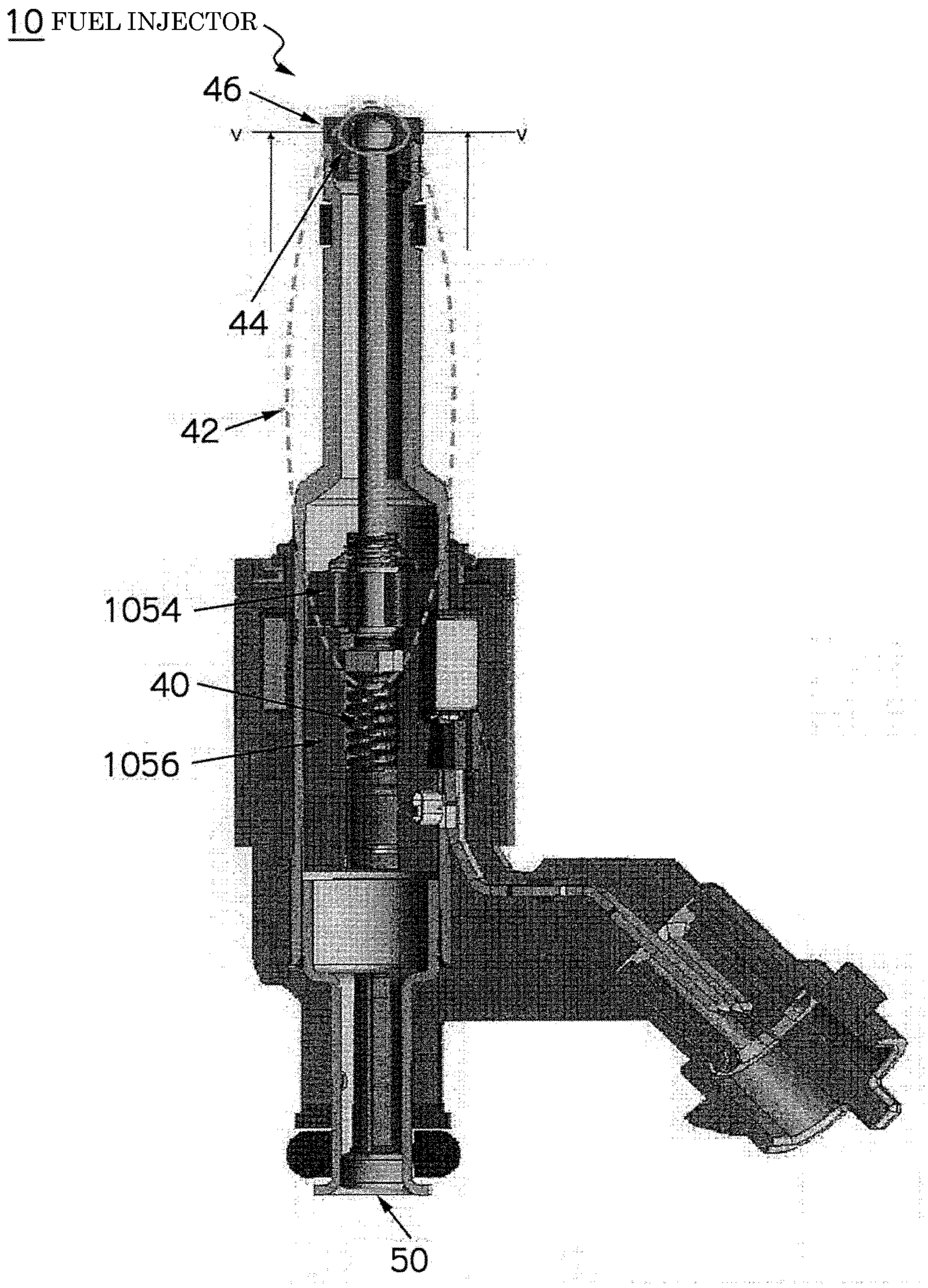


Fig. 4

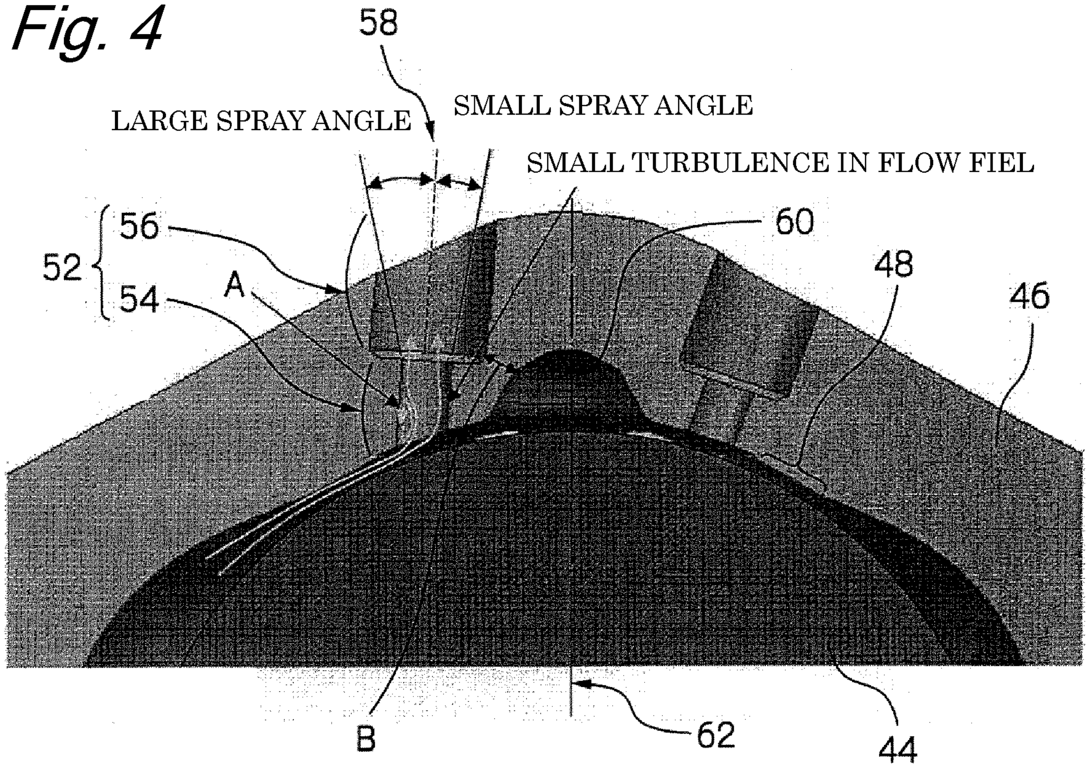

58
LARGE SPRAY ANGLE
SMALL SPRAY ANGLE
SMALL TURBULENCE IN FLOW FIEL
52
56
54
A
60
48
46
B
62
44

Fig. 5

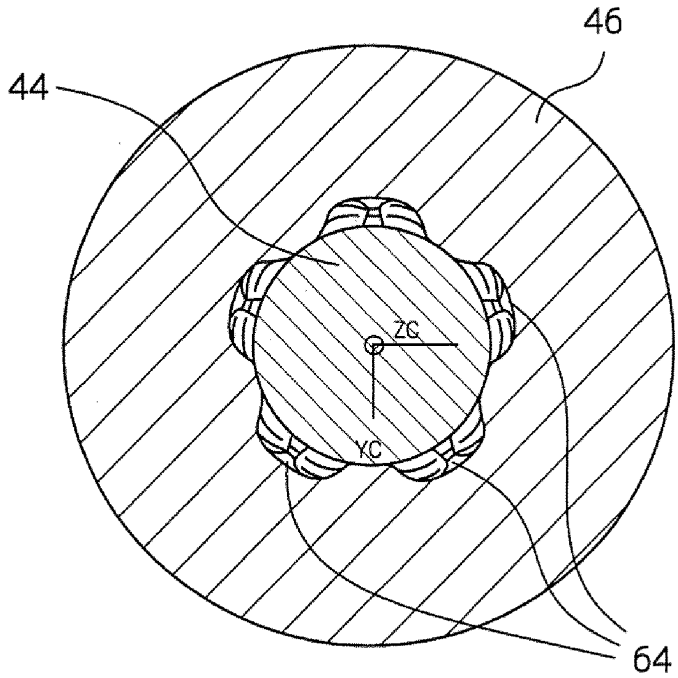

46
44
ZC
YC
64

Fig. 6A

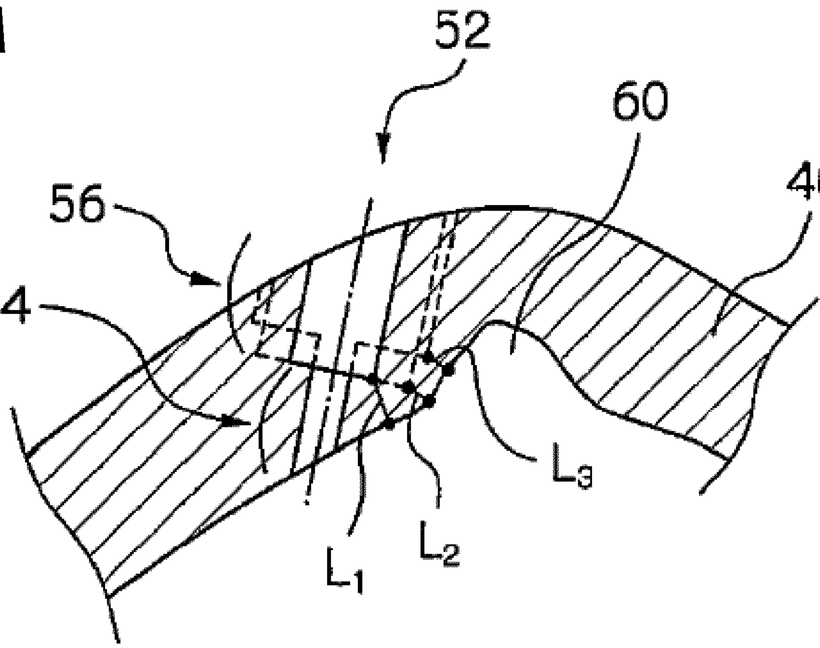
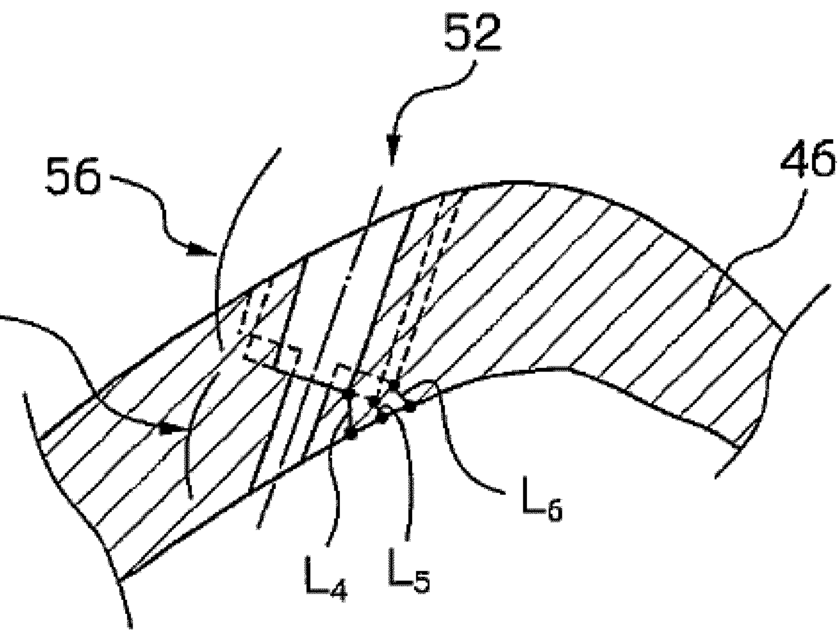


Fig. 6B



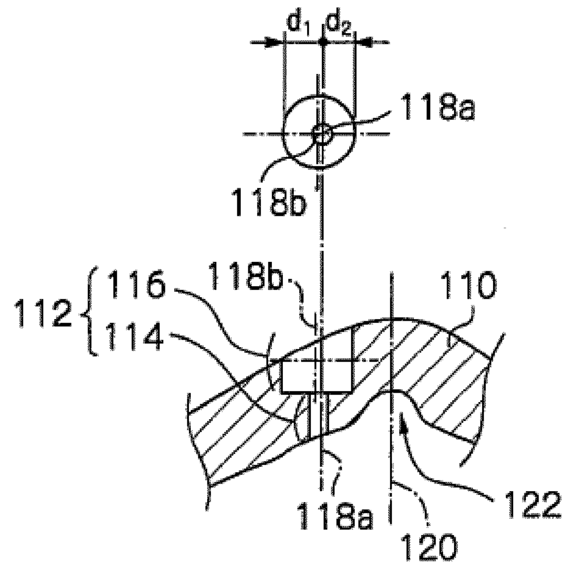


Fig. 7A

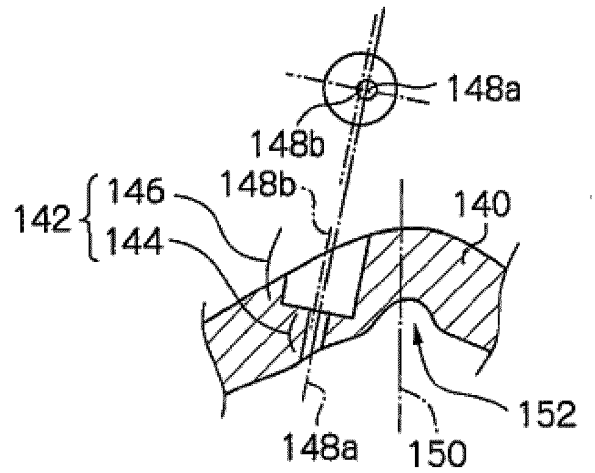


Fig. 7B

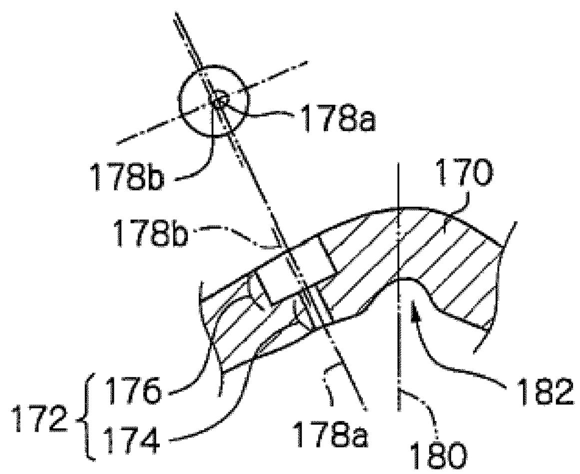


Fig. 7C

Fig. 8

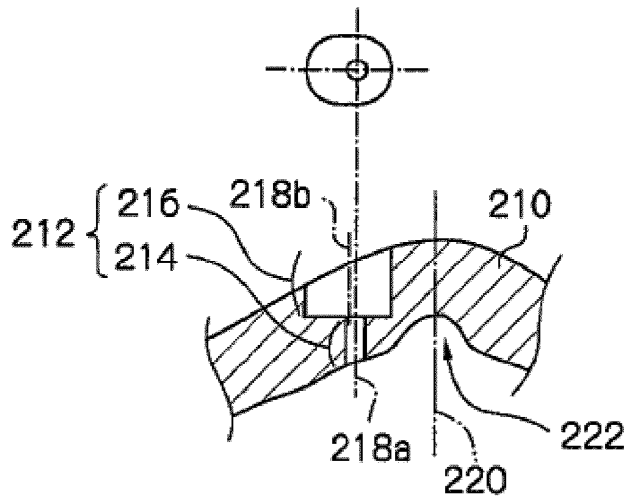


Fig. 9A

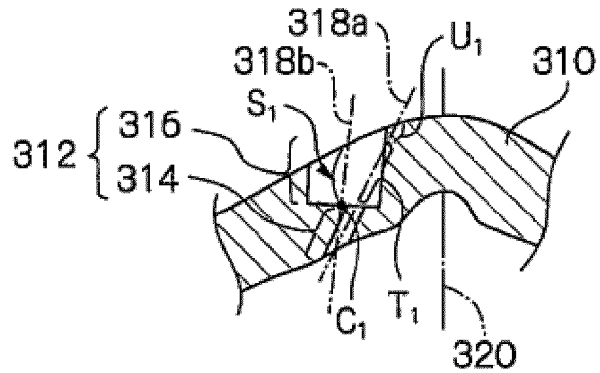


Fig. 9B

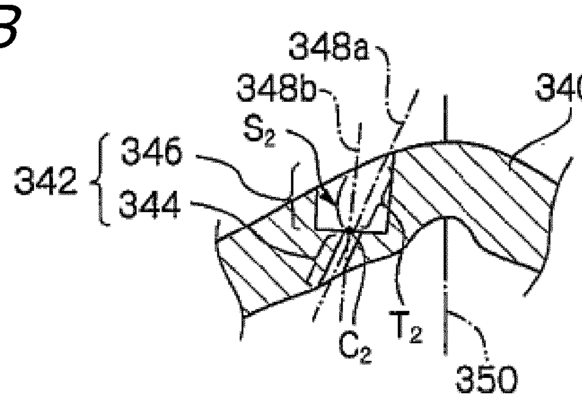


Fig. 10

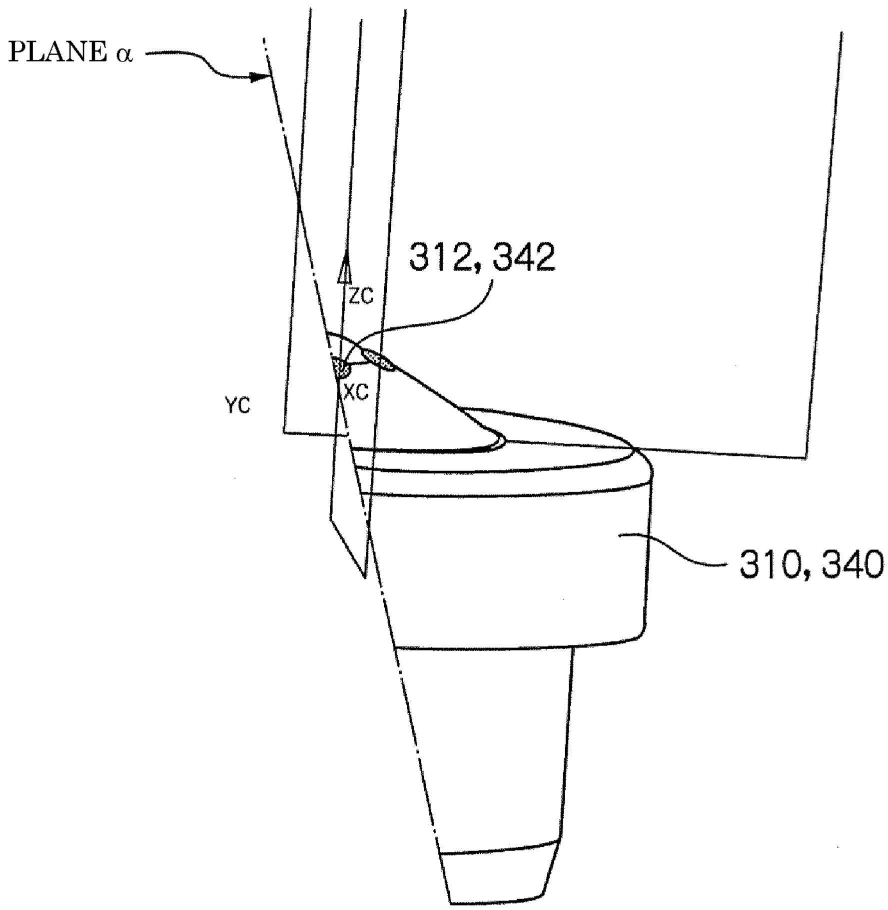


Fig. 11

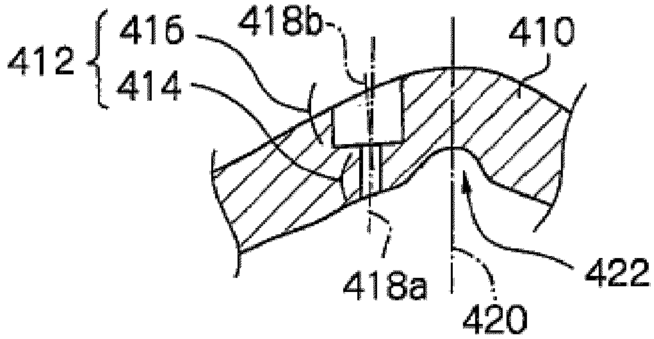

412
416
414
418b
410
418a
420
422

Fig. 12

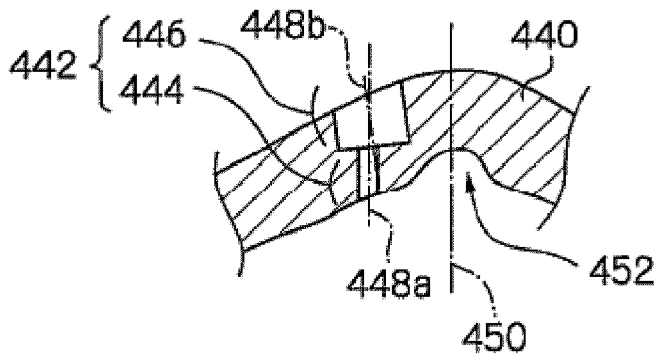

442
446
444
448b
440
448a
450
452

Fig. 13A

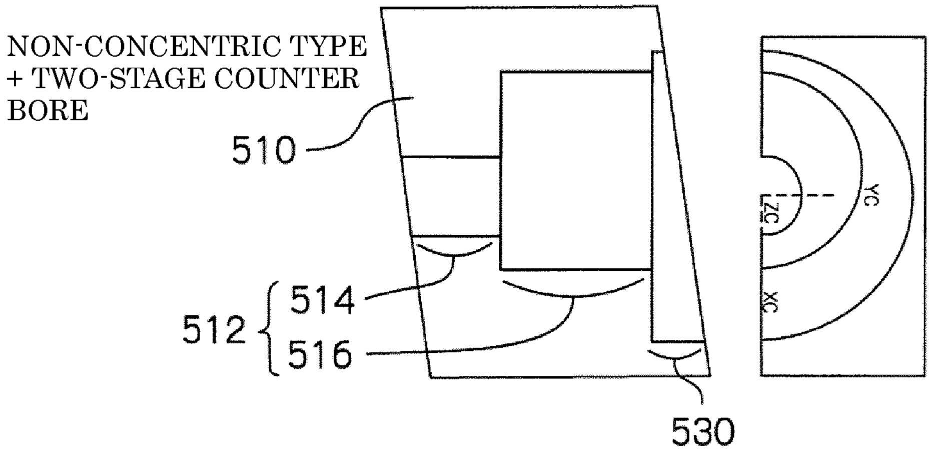


Fig. 13B

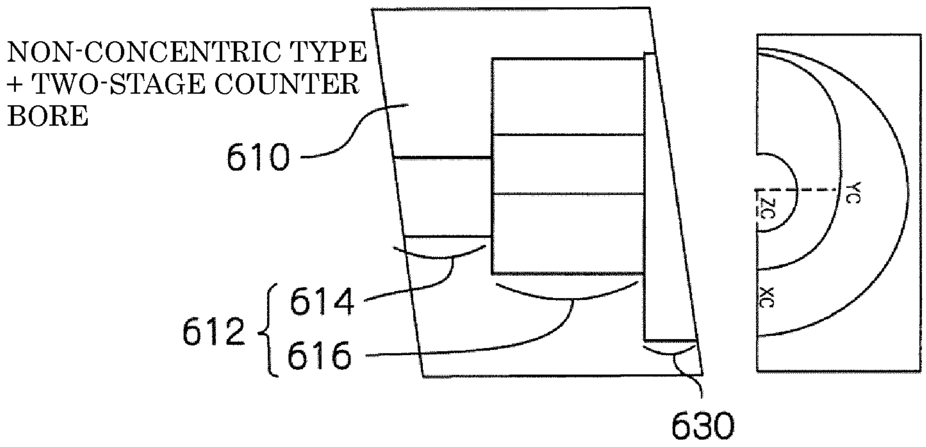


Fig. 13C

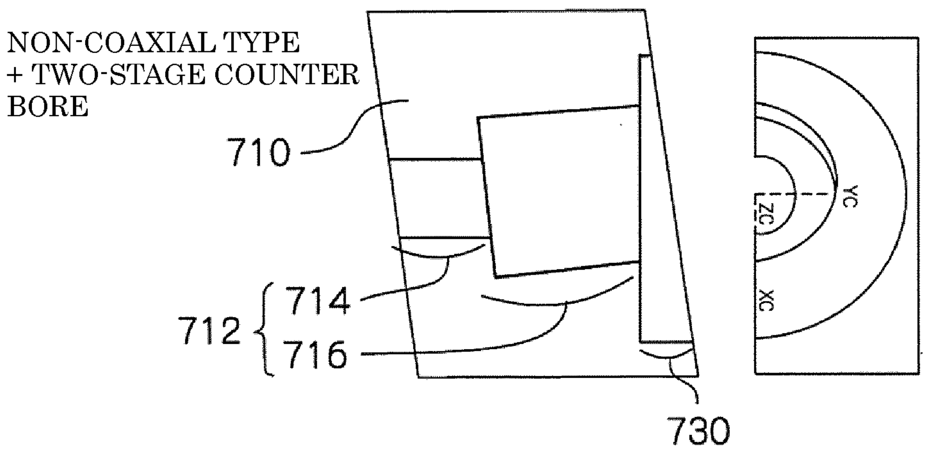


Fig. 14A

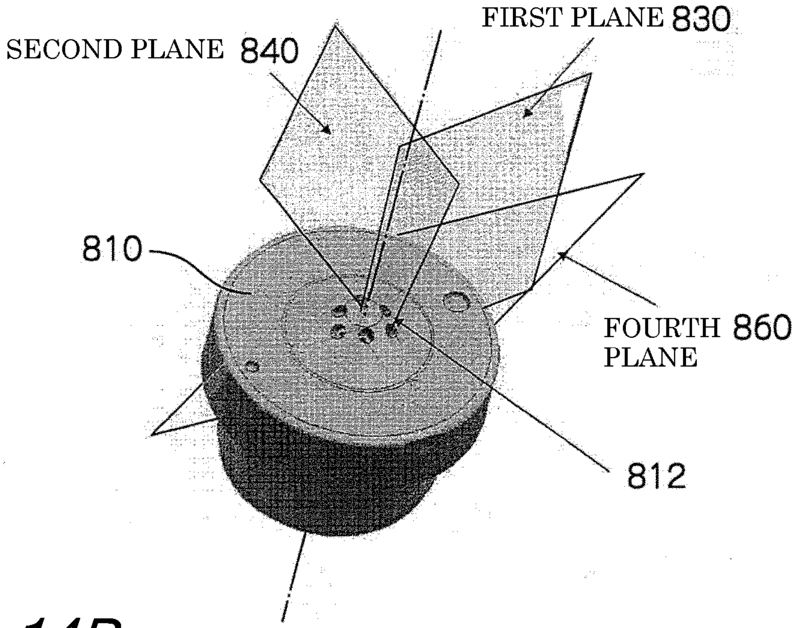


Fig. 14B

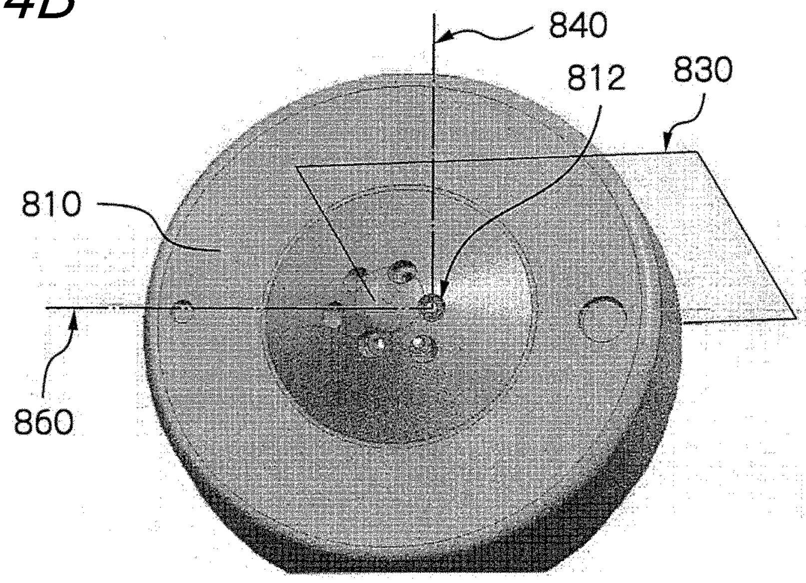


Fig. 14C

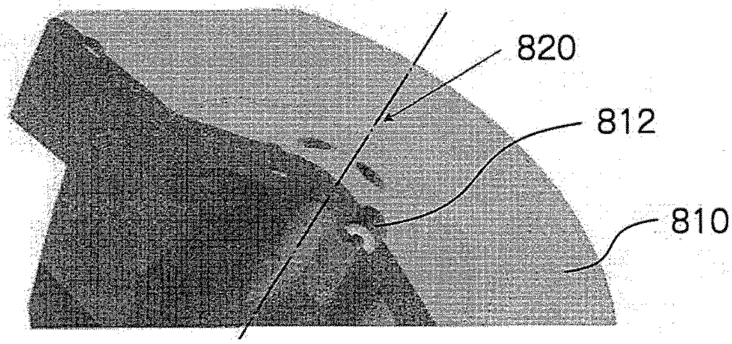


Fig. 15A

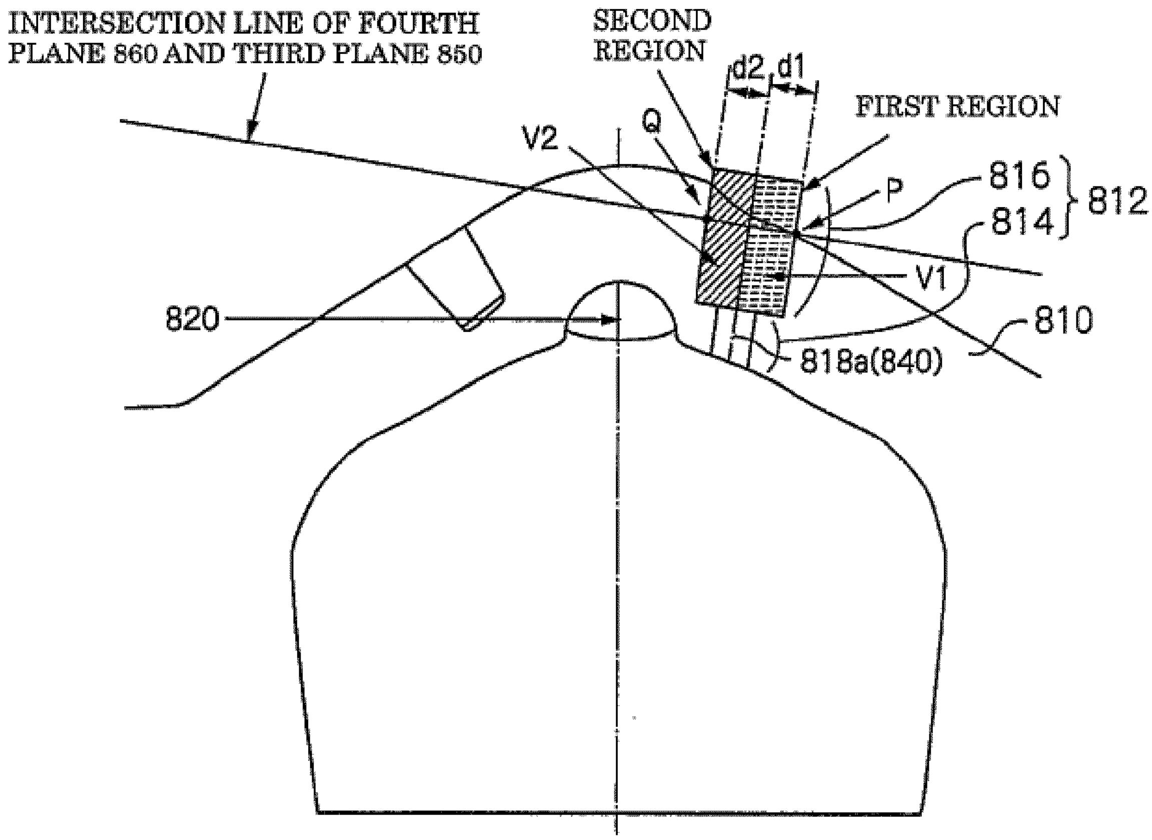
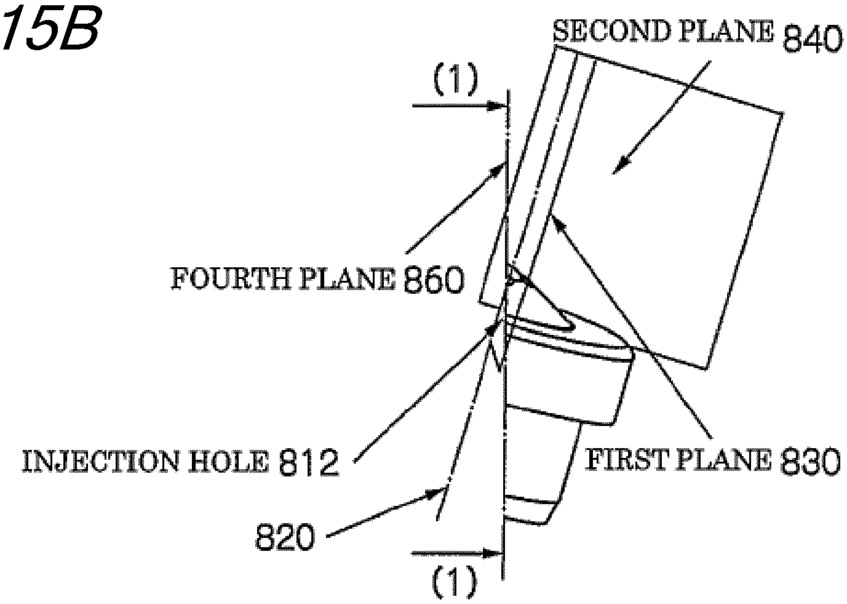


Fig. 15B



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EUROPEAN SEARCH REPORT

Application Number
EP 13 17 1964

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			F02M

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	21 August 2013	Etschmann, Georg

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21-08-2013

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