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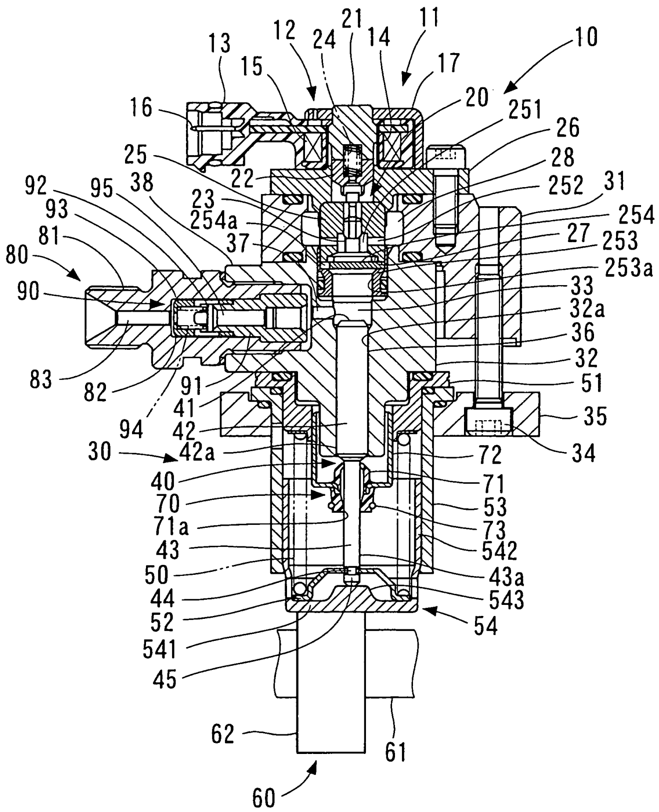
(54) **High pressure fuel pump**

(57) An oil seal (70) is engaged with a small diameter portion (43) of a plunger (40). Thus, even when a diameter of a large diameter portion (42) of the plunger (40) and a diameter of the cylinder (36) are increased, a modification of a design of the oil seal (70), which is engaged with the small diameter portion (43), is not required.

FIG. 1



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Description

[0001] The present invention relates to a high pressure fuel pump.

[0002] There is known a high pressure fuel pump, which pressurizes fuel in a pressurizing chamber by a plunger (See Japanese Unexamined Patent Publication No. 2001-295730 corresponding to US Patent Application Publication No. 2003/0103853 A1 and Japanese Unexamined Patent Publication No. H08-68370 corresponding to US Patent No. 5,567,134). In such a high pressure fuel pump, fuel leakage occurs from a side of a housing, which defines the pressurizing chamber, to a side of a drive means, which drives the plunger, and lubricant oil leakage occurs from the side of the drive means to the side of the housing. Because of this, the high pressure fuel pump recited in each of Japanese Unexamined Patent Publication No. 2001-295730 and Japanese Unexamined Patent Publication No. H08-68370 has a sealing means, which is engaged with an outer peripheral surface of the plunger. In this way, the outer peripheral surface of the plunger is fluid-tightly engaged with an inner peripheral surface of the sealing means to reduce leakage of fuel and leakage of lubricant oil. Furthermore, a high pressure fuel pump recited in Japanese Unexamined Patent Publication No. H11-6475 includes a sealing means that is engaged with an inner peripheral surface of the housing, which is in slidable engagement with the outer peripheral surface of the plunger. In this way, the inner peripheral surface of the housing is fluid-tightly engaged with the sealing means to reduce leakage of fuel and leakage of lubricant oil.

[0003] However, in recent years, a required delivery rate of the high pressure fuel pump is increasing. Because of this, a size of the plunger and a size of the cylinder, which receives the plunger, are increasing. Therefore, in the case of the techniques recited in the above Japanese Unexamined Patent Publications, it is required to newly design a sealing means to correspond with an increase in a diameter of the plunger and an increase in a diameter of the cylinder. Therefore, a product number of the sealing means and a product number of molding dies are disadvantageously increased, and a relatively large number of steps is disadvantageously required for evaluating performance of the newly designed sealing means.

[0004] Furthermore, the sealing means is engaged with the outer peripheral surface of the plunger or with the inner peripheral surface of the cylinder. Thus, when the diameter of the plunger or the diameter of the cylinder is substantially increased, the entire length of the contact area of the sealing means is lengthened. Therefore, the fuel and the oil can be easily leaked from the contact area. It is conceivable to increase the engaging force for engaging between the sealing means and the plunger or the housing, which forms the cylinder. However, when the engaging force is increased, wearing of the sealing means may be induced by the engagement between the sealing means and the plunger or the housing. As a result, the durability and reliability of the sealing means is disadvantageously reduced.

[0005] Furthermore, when the diameter of the plunger is increased, the weight of the plunger is accordingly increased. This causes an increase in inertia of the plunger at the time of reciprocal movement of the plunger. Therefore, the ability of the plunger to follow the movement of the drive means is disadvantageously reduced. In order to increase the ability of the plunger to follow the movement of the drive means, a weight of an urging member, which urges the plunger against the drive means, needs to be increased. As a result, the drive force for driving the plunger is disadvantageously increased, thereby causing a substantial increase in the size.

[0006] Accordingly, it is an objective of the present invention to provide a high pressure fuel pump, which alleviates or eliminates a need for a modification of a design of a sealing means engaged with a plunger even when a diameter of at least a portion of the plunger or a diameter of a cylinder changes. It is another objective of the present invention to provide a high pressure fuel pump, which has a relatively high sealing performance and a relatively high reliability. It is another objective of the present invention to provide a high pressure fuel pump, which limits a substantial increase in a size of the high pressure fuel pump.

[0007] To achieve the objectives of the present invention, there is provided a high pressure fuel pump, which includes a housing, a plunger, a drive means and a sealing means. The housing forms a cylinder therein. The cylinder communicates with a fuel intake passage and a fuel delivery passage in the housing. The plunger is reciprocably, slidably supported in the cylinder and includes an axial end surface, a large diameter portion, a small diameter portion. The axial end surface of the plunger defines a pressurizing chamber in corporation with the housing, and the plunger pressurizes fuel in the pressurizing chamber. The large diameter portion has an outer peripheral surface, which is slidably engaged with an inner peripheral surface of the housing, which forms the cylinder. The small diameter portion has an outer diameter smaller than an outer diameter of the large diameter portion and is connected to an opposite axial end of the plunger, which is opposite from the pressurizing chamber and the large diameter portion. The drive means is for reciprocally driving the plunger. The drive means is arranged at the opposite axial end of the plunger, which is opposite from the pressurizing chamber. The sealing means has a sliding surface, which is fluid-tightly engaged with an outer peripheral surface of the small diameter portion.

[0008] The invention, together with additional objectives, features and advantages thereof, will be best understood from the following description, the appended claims and the accompanying drawings in which:

FIG. 1 is a cross sectional view of a high pressure fuel pump according to a first embodiment of the present invention;

FIG. 2 is a cross sectional view of the high pressure fuel pump of the first embodiment of the present invention, showing a plunger in a top dead center;

FIG. 3 is a cross sectional view of a high pressure fuel pump according to a second embodiment of the present invention;

FIG. 4 is a cross sectional view of a high pressure fuel pump according to a third embodiment of the present invention;

FIG. 5 is a cross sectional view of a high pressure fuel pump according to a fourth embodiment of the present invention;

FIG. 6 is a cross sectional view of a high pressure fuel pump according to a fifth embodiment of the present invention;

FIG. 7 is a cross sectional view of a high pressure fuel pump according to a sixth embodiment of the present invention;

FIG. 8 is a cross sectional view of a high pressure fuel pump according to a seventh embodiment of the present invention;

FIG. 9 is a cross sectional view of a high pressure fuel pump according to an eighth embodiment of the present invention; and

FIG. 10 is a cross sectional view of a high pressure fuel pump according to a ninth embodiment of the present invention.

[0009] Various embodiments of the present invention will be described with reference to the accompanying drawings.

(First Embodiment)

[0010] FIG. 1 shows a high pressure fuel pump according to a first embodiment of the present invention. The high pressure fuel pump 10 of FIG. 1 is used as a fuel pump of a gasoline engine. The high pressure fuel pump 10 pressurizes fuel drawn from a fuel tank and supplies the pressurized fuel to injectors (not shown). The high pressure fuel pump 10 controls a delivery rate of the high pressure fuel by controlling opening and closing of a solenoid valve 11. The high pressure fuel pump 10 includes the solenoid valve 11 and a pump arrangement 30. The pump arrangement 30 pressurizes the drawn fuel and discharges the pressurized fuel. The high pressure fuel pump 10 is not limited to the fuel pump of the gasoline engine and can be alternatively used as a supply pump, which supplies fuel to any other type of internal combustion engine, such as a diesel engine.

[0011] The solenoid valve 11 includes a coil arrangement 12 and a valve arrangement 20. The coil arrangement 12 is fitted around a stationary core 21 of the valve arrangement 20. The coil arrangement 12 is an electromagnetic drive arrangement, which supplies drive force to the valve arrangement 20. The connector 13 is a resin mold, which covers a bobbin 14 and a coil 15 wound around the bobbin 14. A terminal 16 is electrically connected to the coil 15. The cover 17 is made of a metal material and connects between the stationary core 21 and a cover member 26.

[0012] The valve arrangement 20 includes the stationary core 21, a movable core 22, a valve member 23, a valve spring 24, a valve body 25, a sleeve 253 and a stopper 254. The movable core 22 is reciprocably received in the cover member 26. The valve member 23 reciprocates together with the movable core 22. The valve spring 24 urges the movable core 22 in a downward direction in FIG. 1. The valve body 25 has a valve seat 27, against which the valve member 23 is seatable.

[0013] The valve spring 24 urges the movable core 22 in a direction away from the stationary core 21. The stationary core 21 and the movable core 22 form a magnetic circuit. When the coil 15 is energized, the stationary core 21 generates a magnetic attractive force. Thus, the movable core 22 is attracted toward the stationary core 21 in an upward direction in FIG. 1 against the urging force of the valve spring 24. The valve body 25, the sleeve 253 and the stopper 254 are entirely received in a housing cover 31 and a housing main body 32, which form a pump housing of the pump arrangement 30. The housing cover 31 and the housing main body 32 form a housing of the present invention. The cover member 26 is fixed to the housing cover 31.

[0014] The valve body 25 is formed into a tubular body and defines a communication hole 252 therein to communicate between a tubular internal passage 251 and a fuel intake passage 28. The internal passage 251 and the communication hole 252 communicate between the intake passage 28 and a pressurizing chamber 33 through a fuel hole 254a of the stopper 254. When the valve member 23 is seated against the valve seat 27 of the valve body 25, the internal passage 251 is closed. Thus, the communication between the intake passage 28 and the pressurizing chamber 33 is disconnected. Low pressure fuel is supplied from the fuel tank to the intake passage 28 by a low pressure pump (not shown). When the connection between the intake passage 28 and the pressurizing chamber 33 is opened and closed by the valve portion 20, the rate of fuel delivered from the pressurizing chamber 33 to the intake passage 28 is changed. Movement of the valve member 23 toward the pressurizing chamber 33 side is limited when the valve member 23 contacts the stopper 254.

[0015] The pump housing of the pump arrangement 30 includes the housing cover 31 and the housing main body 32. The housing cover 31 forms the intake passage 28 and is formed separately from the housing main body 32. The housing cover 31 covers a pressurizing chamber 33 side of the housing main body 32 and is connected to an attachment member 35 by a plurality of bolts 34. The housing main body 32 is clamped between the housing cover 31 and the attachment member 35 due to the connecting force of the bolts 34.

[0016] The housing main body 32 forms a cylinder 36, in which a plunger 40 is reciprocably supported. The pressurizing chamber 33 is defined by an inner peripheral surface 32a of the housing main body 32, an inner peripheral surface 253a of the sleeve 253, a plunger 40 side end surface of the stopper 254 and an end surface 41 of the plunger 40. Here, the inner peripheral surface 32a of the housing main body 32 forms the cylinder 36. A plunger spring 50, which serves as a resilient member, contacts a spring seat 51 at one end and also contacts a seat 52 at the other end. The spring seat 51 and a tappet guide 53 are clamped between the housing main body 32 and the attachment member 35. The tappet guide 53 is formed into a generally cylindrical body, and an inner peripheral surface of the tappet guide 53 is slidably engaged with an outer peripheral wall of a tappet 54. In this way, the tappet guide 53 supports the tappet 54 in an axially reciprocable manner. The tappet 54 has a base 541 and a tubular portion 542. The tappet 54 reciprocates in an axial direction at a location radially inward of the tappet guide 53.

[0017] The plunger 40 has a large diameter portion 42, a small diameter portion 43, a reduced diameter portion (or a recess of any shape recessed from an outer peripheral surface of the small diameter portion) 44 and a head 45. The large diameter portion 42 has an outer diameter, which is larger than an outer diameter of the small diameter portion 43 and an outer diameter of the reduced diameter portion 44. In the plunger 40, the large diameter portion 42, the small diameter portion 43, the reduced diameter portion 44 and the head 45 are formed integrally. An end surface 41 of the large diameter portion 42, which is opposite from the small diameter portion 43, defines the pressurizing chamber 33. An outer peripheral wall (an outer peripheral surface) 42a of the large diameter portion 42 slides along the inner peripheral surface 32a of the housing main body 32, which forms the cylinder 36. The outer diameter of the small diameter portion 43 is smaller than the outer diameter of the large diameter portion 42 but is larger than the outer diameter of the reduced diameter portion 44. The small diameter portion 43 is connected to an opposite end of the large diameter portion 42, which is opposite from the pressurizing chamber 33. The reduced diameter portion 44 has the smallest diameter in the plunger 40. The reduced diameter portion 44 is formed between the small diameter portion 43 and the head 45. The head 45 is connected to the reduced diameter portion 44 at the opposite end of the plunger 40, which is opposite from the pressurizing chamber 33. An outer diameter of the head 45 is generally the same as that of the small diameter portion 43. The head 45 contacts a pedestal 543, which is formed in the base 541 of the tappet 54. The plunger 40 is radially inwardly recessed at a location between the small diameter portion 43 and the head 45 due to the presence of the reduced diameter portion 44.

[0018] In the present embodiment, the outer diameter of the reduced diameter portion 44 is set to be equal to or greater than 3 mm. The plunger 40 receives large axial force from high pressure fuel of the pressurizing chamber 33 and a drive means 60. Thus, the sufficient outer diameter of the plunger 40 needs to be maintained to achieve the required strength of the plunger 40. Therefore, in the present embodiment, the outer diameter of the reduced diameter portion 44, which has the smallest diameter in the plunger 40, is set to be equal to or greater than 3 mm.

[0019] The drive means 60 includes a valve camshaft 61 of the engine and a pump cam 62, which is arranged in the valve camshaft 61. The pump cam 62 is rotated integrally with the valve camshaft 61. An outer end surface of the tappet 54, which is located on an axially outer side of the base 541, contacts the pump cam 62. In this way, when the pump cam 62 is rotated together with the valve camshaft 61, the tappet 54 is axially reciprocated in conformity with a cam profile of the pump cam 62.

[0020] In contrast, an inner end surface of the tappet 54, which is located on an axially inner side of the base 541, contacts the seat 52. The plunger spring 50 has an axially expanding force. In this way, the plunger spring 50, which contacts both of the spring seat 51 and the seat 52, urges the seat 52 and the tappet 54 toward the pump camshaft 62. An inner peripheral edge of the seat 52 is engaged with the reduced diameter portion 44 of the plunger 40. The plunger 40 is radially inwardly recessed due to the presence of the reduced diameter portion 44. The inner peripheral edge of the seat 52 is engaged with the reduced diameter portion 44, which is radially inwardly recessed in the plunger 40. In this way, the plunger spring 50 urges the tappet 54, which is engaged with the seat 52, toward the pump cam 62 side. Also, the plunger spring 50 urges the plunger 40 toward the pump cam 62 side through the seat 52, which is engaged with the reduced diameter portion 44. With above structure, the plunger 40 and the tappet 54 are reciprocated in conformity with the cam profile of the pump cam 62 from a bottom dead center (also referred as a bottom dead center position) shown in FIG. 1 to a top dead center (also referred to as a top dead center position) shown in FIG. 2.

[0021] The spring seat 51 is formed into a tubular body. An oil seal 70, which serves as a sealing means, is arranged on a drive means 60 side of the spring seat 51. In this way, the oil seal 70 is arranged on an opposite side of the housing main body 32, which is opposite from the pressurizing chamber 33 in the axial direction of the plunger 40. That is, the oil seal 70 is arranged outside of the housing main body 32.

[0022] The oil seal 70 is formed into a tubular body, which surrounds the outer peripheral part of the plunger 40. The oil seal 70 includes a sealing portion 71, a supporting portion 72 and a ring 73. An inner peripheral sliding surface 71a of the sealing portion 71 is slidably engaged with an outer peripheral surface 43a of the small diameter portion 43 of the plunger 40. One axial end of the supporting portion 72 supports the sealing portion

71. The other axial end of the supporting portion 72 is fixed to an inner peripheral part of the spring seat 51. The supporting portion 72 is fixed to the spring seat 51 by, for example, press fitting, welding or the like. The ring 73 exerts radially inwardly clamping force and thereby radially inwardly urges the sealing portion 71. In this way, the sealing portion 71 is supported by the supporting portion 72 and is urged against the small diameter portion 43 of the plunger 40. As shown in FIGS. 1 and 2, during the traveling period of the plunger 40 from the bottom dead center to the top dead center, the oil seal 70 is engaged with the small diameter portion 43 of the plunger 40.

[0023] The sealing portion 71 is made of a resiliently deformable material, such as a rubber material or a resin material. An inner peripheral surface of the sealing portion 71 forms a sliding surface 71a, which is fluid tightly engaged with the outer peripheral surface 43a of the small diameter portion 43 of the plunger 40. The fuel, which is pressurized in the pressurizing chamber 33, is partially leaked outside of the housing main body 32, specifically, to the drive means 60 side of the housing main body 32 through the sliding area between the plunger 40 and the housing main body 32. The leaked fuel, which is leaked between the plunger 40 and the housing main body 32, lubricates between the plunger 40 and the housing main body 32.

[0024] In contrast, lubricant oil is supplied from the drive means 60 side to the tapped 54 to facilitate the sliding movement of the tappet 54 relative to the tappet guide 53. Thus, at the oil seal 70, a space outside of the supporting portion 72 is filled with the lubricant oil, and a space inside of the supporting portion 72 is filled with the fuel. The sealing portion 71 is fluid tightly engaged with the small diameter portion 43 of the plunger 40, so that the oil seal 70 limits mixing of the fuel and the lubricant oil. The fuel, which is filled in the space inside of the supporting portion 72 of the oil seal 70, is returned to, for example, the fuel tank and/or the intake passage 28 through a return passage (not shown).

[0025] A delivery valve arrangement 80 is provided to the housing main body 32. The delivery valve arrangement 80 includes a casing 81. The housing main body 32 forms a fuel delivery passage 37, which is communicated with the pressurizing chamber 33. The housing main body 32 has a tubular portion 38 at radially outward of the delivery passage 37. The casing 81 is formed into a tubular body and receives a delivery valve 90. One axial end of the casing 81 is fixed to the tubular portion 38. In the present embodiment, the casing 81 is fixed to the housing main body 32 by, for example, thread engagement. The casing 81 has a receiving portion 82 and a fuel passage 83 therein. The receiving portion 82 receives the delivery valve 90.

[0026] The delivery valve 90 is received inside of the casing 81. The delivery valve 90 includes a valve body 91, a valve member 92, a passage forming member 93 and a spring 94. The valve body 91 is formed into a tubular body and is arranged inside of the casing 81. A fuel passage 95, which is communicated with the delivery passage 37, is formed in the valve body 91. The valve member 92 is seatable against a passage forming member 93 side end of the valve body 91. The passage forming member 93 is arranged on an opposite side of the valve body 91, which is opposite from the housing main body 32. The valve member 92 is formed into a circular disk-like body and is reciprocable in the passage forming member 93 in the axial direction of the passage forming member 93. The spring 94 urges the valve member 92 toward the valve body 91 side.

[0027] When the pressure of the fuel passage 95 of the valve body 91, which is communicated with the delivery passage 37, is increased through the pressurization of the fuel in the pressurizing chamber 33, the urging force of the fuel of the fuel passage 95, which urges the valve member 92, is increased. Then, when the force, which is applied from the fuel of the fuel passage 95 to the valve member 92, becomes larger than the force, which is applied from the fuel of the fuel passage 83 and the spring 94 to the valve member 92, the valve member 92 is lifted away from the valve body 91. In this way, the delivery passage 37 and the fuel passage 83 of the casing 81 are communicated with each other, and therefore the pressurized fuel is delivered from the high pressure fuel pump 10. In contrast, when the pressure of the fuel passage 83 is higher than that of the delivery passage 37, the valve member 92 is seated against the valve body 91, and therefore the fuel flow from the fuel passage 83 to the delivery passage 37 is stopped. That is, the delivery valve 90 serves as a check valve, which only permits the flow of the fuel from the pressurizing chamber 33 side to the outside of the high pressure fuel pump 10.

[0028] In the high pressure fuel pump 10, the plunger 40 and the tappet 54 are reciprocated from the bottom dead center shown in FIG. 1 to the top dead center shown in FIG. 2 in conformity with the cam profile of the pump cam 62. When the plunger 40 is moved from the top dead center to the bottom dead center, the solenoid valve 11 is opened. Thus, a predetermined quantity of fuel is supplied from the intake passage 28 to the pressurizing chamber 33. When the plunger 40 is moved from the bottom dead center to the top dead center, the fuel in the pressurizing chamber 33 is discharged into the intake passage 28. When a predetermined quantity of fuel is discharged from the pressurizing chamber 33 into the intake passage 28, the solenoid valve 11 is closed. The fuel in the pressurizing chamber 33 is pressurized when the plunger 40 is moved upward. When the pressure of the fuel in the pressurizing chamber 33 is increased, the pressure of the fuel in the delivery passage 37 is also increased. When the pressure of the fuel in the delivery passage 37 becomes larger than the pressure of the fuel in the fuel passage 83, the delivery valve 90 is opened. Thus, the fuel is discharged from the pressurizing chamber 33 to the outside of the high pressure fuel pump 10.

[0029] In the first embodiment, the oil seal 70 is engaged with the small diameter portion 43 of the plunger 40. Thus, even when the outer diameter of the large diameter portion 42 of the plunger 40 and the inner diameter of the cylinder 36 are increased, it is not required to change the diameter of the oil seal 70, which is engaged with the small diameter portion 43. As a result, even when the specification is changed to change, for example, the required delivery rate of the high pressure fuel pump 10 by changing the outer diameter of the large diameter portion 42 of the plunger 40 and the inner diameter of the cylinder 36, it is not required to change the design of the oil seal 70. Furthermore, since it is not required to change the design of the oil seal 70 in conformity with the plunger 40, an increase in the product number of the oil seals 70 and an increase in the product number of dies for manufacturing the oil seals 70 can be limited, and the number of steps for testing the performance of the oil seals 70 can be reduced.

[0030] Furthermore, in the first embodiment, the oil seal 70 is engaged with the small diameter portion 43 of the plunger 40. Thus, even when the outer diameter of the large diameter portion 42 of the plunger 40 is increased, an entire length of the contacting area between the plunger 40 and the oil seal 70 is not changed. Therefore, even when the diameter of the large diameter portion 42 of the plunger 40 is substantially increased, the required sealing performance for sealing between the plunger 40 and the oil seal 70 can be easily achieved. Furthermore, it is not required to apply a large force to urge the oil seal 70 against the plunger 40. Thus, the friction between the oil seal 70 and the plunger 40 is reduced, and therefore the reliability and durability thereof are improved.

[0031] Furthermore, according to the first embodiment, the outer diameter of the large diameter portion 42 is increased without changing the outer diameter of the small diameter portion 43. Thus, even when the outer diameter of the large diameter portion 42 is increased, an increase in the entire weight of the plunger 40 is limited. When the weight of the plunger 40 is increased, the inertia of the plunger 40 at the time of the reciprocal movement of the plunger 40 is increased. As in the first embodiment, in the case of driving the plunger 40 by the pump cam 62, when the inertia of the plunger 40 becomes excessively large, the abilities of the plunger 40 and of the tappet 54 to follow the cam profile of the pump cam 62 and thereby to axially reciprocate are deteriorated. In order to increase the abilities of the plunger 40 and of the tappet 54 to follow the cam profile of the pump cam 62, the urging force of the plunger spring 50 needs to be increased. The increase of the urging force of the plunger spring 50 causes a substantial increase in the size of the plunger spring 50. When the size of the plunger spring 50 is substantially increased, the size of the tappet 54 and the size the tappet guide 53 for receiving the tappet 54 are accordingly substantially increased. Furthermore, when the urging force of the plunger spring 50 is increased, the required drive force of the drive means 60 for driving the plunger 40 and the tappet 54 is increased. Thus, the size of the drive means 60 needs to be substantially increased to achieve the required drive force. Therefore, the entire size of the high pressure fuel pump 10 needs to be substantially increased to correspond with the increase in the outer diameter of the plunger 40. However, according to the first embodiment, even when the outer diameter of the large diameter portion 42 is increased, an increase in the entire weight of the plunger 40 can be minimized. As a result, it is not required to substantially increase the size of the plunger spring 50, and therefore a substantial increase in the size of the high pressure fuel pump 10 can be limited.

(Second to Fifth Embodiments)

[0032] FIGS. 3-6 indicate second to fifth embodiments, respectively, of the present invention. In the following description, components similar to those of the first embodiment will be indicated by the same numerals and will not be described again for the sake of simplicity.

[0033] In the second embodiment, as shown in FIG. 3, the shape of the oil seal is different from that of the first embodiment. In the second embodiment, the housing main body 32 further extends toward the drive means side in comparison to that of the first embodiment. A drive means 60 side end of the housing main body 32 has a receiving chamber 321, which is recessed on a pressurizing chamber 33 side thereof. The oil seal 170 is arranged in the receiving chamber 321 of the housing main body 32. The oil seal 170 includes a sealing portion 171, a supporting portion 172 and a ring 173. The sealing portion 171 has a sliding surface 171a, which is slidably engaged with the outer peripheral surface 43a of the small diameter portion 43 of the plunger 40. One end of the supporting portion 172 supports the sealing portion 171. The other end of the supporting portion 172 is fixed to the housing main body 32. The housing main body 32 and the supporting portion 172 are securely connected to each other by, for example, press fitting, welding or the like. According to the second embodiment, the total axial length of the supporting portion 172 of the oil seal 170 can be reduced.

[0034] In the third embodiment, as shown in FIG. 4, the shape of the oil seal is different from that of the first embodiment. In the third embodiment, the housing main body 32 further extends toward the drive means 60 side in comparison to that of the first embodiment. A drive means 60 side end of the housing main body 32 has a receiving chamber 322, which is recessed on a pressurizing chamber 33 side thereof. The oil seal 270 is provided in the receiving chamber 322 of the housing main body 32. The oil seal 270 includes a sealing portion 271 and a ring 273. The ring 273 is fitted into a groove 323 of the housing main body 32. In this way, the ring 273 supports the sealing portion 271 from a side that is opposite from the pressurizing chamber 33. According to the third embodiment, the portion, which corresponds to the supporting portion of the oil seal, can be omitted. As a result, the number of the components can be reduced.

[0035] In the fourth embodiment, as shown in FIG. 5, the way of installing the oils seal is different from that of the first embodiment. In the fourth embodiment, the supporting portion 72 of the oil seal 70 is installed to the housing main body 32 rather than the spring seat 51. That is, the supporting portion 72 is fixed to the outer peripheral part of the housing main body 32 by, for example, press fitting, welding or the like.

[0036] In the fifth embodiment, as shown in FIG. 6, the shape of the plunger 40 is different from that of the first embodiment. In the fifth embodiment, the large diameter portion 42 of the plunger 40 is enlarged in comparison to that of the first embodiment. When the size of the plunger 40 is substantially increased to increase the flow rate of the fuel, which is delivered from the high pressure fuel pump 10, the large diameter portion 42 of the plunger 40 may be further substantially enlarged, as shown in FIG. 6. In this case, in the plunger 40, only the outer diameter of the large diameter portion 42 is increased, and the outer diameter of the small diameter portion 43 is kept at the constant value. Thus, the designing of the oil seal 70 is not required, and an increase in the entire length of the contact area between the plunger 40 and the oil seal 70 and an increase in the weight of the plunger 40 will not occur.

(Sixth Embodiment)

[0037] FIG. 7 shows a high pressure fuel pump according to a sixth embodiment of the present invention. In the following description, components similar to those of the first embodiment will be indicated by the same numerals and will not be described again for the sake of simplicity.

[0038] In the sixth embodiment, as shown in FIG. 7, the shape of the oil seal is different from that of the first embodiment. According to the sixth embodiment, an oil seal 370 includes a sealing portion 371 and a supporting portion 372. On end of the supporting portion 372 supports the sealing portion 371. An inner peripheral part of the sealing portion 371 forms a sliding surface 371a. The other end of the supporting portion 372, which is opposite from the sealing portion 371, includes a fixing portion 373. The fixing portion 373 is directly installed to the housing main body 32. The housing main body 32 includes a tubular portion 324, which projects toward the valve camshaft 61 side. The tubular portion 324 is formed into a tubular body, which is communicated with the cylinder 36. The fixing portion 373 is connected to the tubular portion 324. The fixing portion 373 is fixed to the tubular portion 324 of the housing main body 32 by, for example, press fitting, welding or the like.

[0039] When the plunger 40 is in the bottom dead center as shown in FIG. 7, the fixing portion 373 is located on a valve camshaft 61 side of a valve camshaft 61 side end of the large diameter portion 42. The bottom dead center is a position where the plunger 40 is located in the closest position relative to the valve camshaft 61, and thereby the volume of the pressurizing chamber 33 is maximized. When the position of the fixing portion 373 is set in the above manner, the large diameter portion 42 of the plunger 40 will not be moved beyond the fixing portion 373 on the valve camshaft 61 side of the fixing portion 373.

[0040] In a case where the oil seal 370 is directly fixed to the housing main body 32, the fixing portion 373 is press fitted or welded to the housing main body 32. When the fixing portion 373 is press fitted or is welded, the tubular portion 324 of the housing main body 32 may possibly be deformed in some cases. When the housing main body 32 is deformed, the cylinder 36, in which the plunger 40 is guided, is deformed to disturb smooth movement of the plunger 40. Therefore, in the first embodiment, the supporting portion 372 is fixed to the spring seat 51, which is formed separately from the housing main body 32. In this way, in the first embodiment, even though the spring seat 51 may be deformed due to the fixing of the supporting portion 372 to the spring seat 51, the deformation of the housing 32 can be effectively limited.

[0041] In the sixth embodiment, when the fixing portion 373 is directly fixed to the tubular portion 324 of the housing main body 32, the tubular portion 324 may possibly be slightly deformed. However, as discussed above, when the plunger 40 is in the bottom dead center, the fixing portion 373 is located on the valve camshaft 61 side of the valve camshaft 61 side end of the large diameter portion 42. Thus, at the time of reciprocating the plunger 40, the large diameter portion 42 of the plunger 40 will not enter the radially inner side of the fixing portion 373. Therefore, only the small diameter portion 43 of the plunger 40 is moved at the radially inner side of the fixing portion 373. As a result, even when the housing main body 32 is deformed, the relative sliding movement between the outer peripheral wall 42a of the large diameter portion 42 of the plunger 40 and the inner peripheral surface 32a of the cylinder 36 will not be disturbed, and therefore the smooth reciprocal movement of the plunger 40 will not be disturbed.

[0042] Furthermore, in the sixth embodiment, the oil seal 370 can be directly fixed to the housing main body 32. Thus, there is no need to provide a dedicated separate component, such as the spring seat 51 of the first embodiment, which limits the deformation of the housing main body 32. In this way, many components, such as the deformation limiting component for limiting the deformation of the housing main body 32 and the sealing member for sealing between such a deformation limiting component and the other component (e.g., the housing main body 32), become unnecessary. As a result, the number of components and the number of assembling steps can be reduced.

(Seventh to Ninth Embodiments)

[0043] FIGS. 8 to 10 show the high pressure fuel pumps of seventh to ninth embodiments, respectively. In the following description, components similar to those of the first embodiment will be indicated by the same numerals and will not be described again for the sake of simplicity.

[0044] In the seventh embodiment, as shown in FIG. 8, an oil seal 470 includes sealing portions 471 and a holder 472. The sealing portions 471 are held by the holder 472. Similar to the sixth embodiment, the holder 472 is directly fixed to the housing main body 32. The holder 472 is fixed to the housing main body 32 by, for example, press fitting, welding or the like. The sealing portions 171 are provided at two axial locations along the plunger 40. Each sealing member 471 may be a rubber sealing member (e.g., an O-ring or an X-ring) or a resin sealing member, which is made into a ring form.

[0045] In the eighth embodiment, as shown in FIG. 9, an oil seal 570 includes sealing portions 571 and a holder 572. The sealing portions 571 are held by the holder 572. The holder 572 is fixed to an inner peripheral part of the housing main body 32. The holder 572 is fixed to the housing main body 32 by, for example, press fitting, welding or the like or is held by a ring 580. The sealing members 571 are not limited to rubber sealing members. For example, the sealing members 571 may be resin sealing members.

[0046] In the ninth embodiment, as shown in FIG. 10, an oil seal 670 includes sealing portions 671, 672, a supporting portion 673 and a holder 674. The sealing portion 671 is supported by the supporting portion 673, and the sealing portion 672 is held by the holder 674. The supporting portion 673 and the holder 674 are fixed to the inner peripheral part of the housing main body 32. The holder 674 is held by the housing main body 32. The supporting portion 673 is fixed to the housing main body 32 by, for example, press fitting, welding or the like. In the ninth embodiment, the sealing member 671 is a rubber sealing member, and the sealing member 672 is a resin sealing member. As discussed above, it is possible to have a combination of different sealing members, which are made of different materials, respectively.

[0047] The present invention is not limited to the above specific embodiments and can be embodied in various ways without departing from the scope of the invention.

[0048] Additional advantages and modifications will readily occur to those skilled in the art. The invention in its broader terms is therefore not limited to the specific details, representative apparatus, and illustrative examples shown and described. Also, it should be noted that the component (s) of any one of the above embodiments may be replaced with or combined with the component (s) of any other one of the above embodiments without departing from the spirit and scope of the invention.

[0049] An oil seal (70) is engaged with a small diameter portion (43) of a plunger (40). Thus, even when a diameter of a large diameter portion (42) of the plunger (40) and a diameter of the cylinder (36) are increased, a modification of a design of the oil seal (70), which is engaged with the small diameter portion (43), is not required.

Claims

1. A high pressure fuel pump comprising:

a housing (31, 32) that forms a cylinder (36) therein, wherein the cylinder (36) communicates with a fuel intake passage (28) and a fuel delivery passage (37) in the housing (31, 32);
a plunger (40) that is reciprocably, slidably supported in the cylinder (36) and includes:

an axial end surface (41) that defines a pressurizing chamber (33) in corporation with the housing (31, 32), wherein the plunger (40) pressurizes fuel in the pressurizing chamber (33);
a large diameter portion (42) that has an outer peripheral surface (42a), which is slidably engaged with an inner peripheral surface (32a) of the housing (31, 32), which forms the cylinder (36); and
a small diameter portion (43) that has an outer diameter smaller than an outer diameter of the large diameter portion (42) and is connected to an opposite axial end of the plunger (40), which is opposite from the pressurizing chamber (33) and the large diameter portion (42);

a drive means (60) for reciprocally driving the plunger (40), wherein the drive means (60) is arranged at the opposite axial end of the plunger (40), which is opposite from the pressurizing chamber (33); and
a sealing means (70, 170, 270, 370, 470, 570, 670) that has a sliding surface, which is fluid-tightly engaged with an outer peripheral surface (43a) of the small diameter portion (43).

2. The high pressure fuel pump according to claim 1, further comprising:

a resilient member (50) that urges the plunger (40) toward the drive means (60) side; and
a seat (52) that conducts an urging force of the resilient member (50) to the plunger (40), wherein the plunger (40) further includes a reduced diameter portion (44), which is engaged with the seat (52) and is located at an opposite end of the small diameter portion (43) that is opposite from the large diameter portion (42), and an outer diameter of the reduced diameter portion (44) is smaller than the outer diameter of the small diameter portion (43).

3. The high pressure fuel pump according to claim 2, wherein the outer diameter of the reduced diameter portion (44) is equal to or greater than 3 mm.

4. The high pressure fuel pump according to any one of claims 1 to 3, wherein:

the sealing means (70, 170, 270, 370, 470, 570, 670) includes a fixing portion (373), which is fixed to the housing (31, 32); and
the fixing portion (373) is located closer to the drive means (60) than a drive means side end of the large diameter portion (42) when the plunger (40) is positioned in a bottom dead center.

5. The high pressure fuel pump according to any one of claims 1 to 4, wherein the sealing means (70, 370, 470) is located axially outward of the housing (31, 32) on a side opposite from the pressurizing chamber (33) of the cylinder (36).

FIG. 1

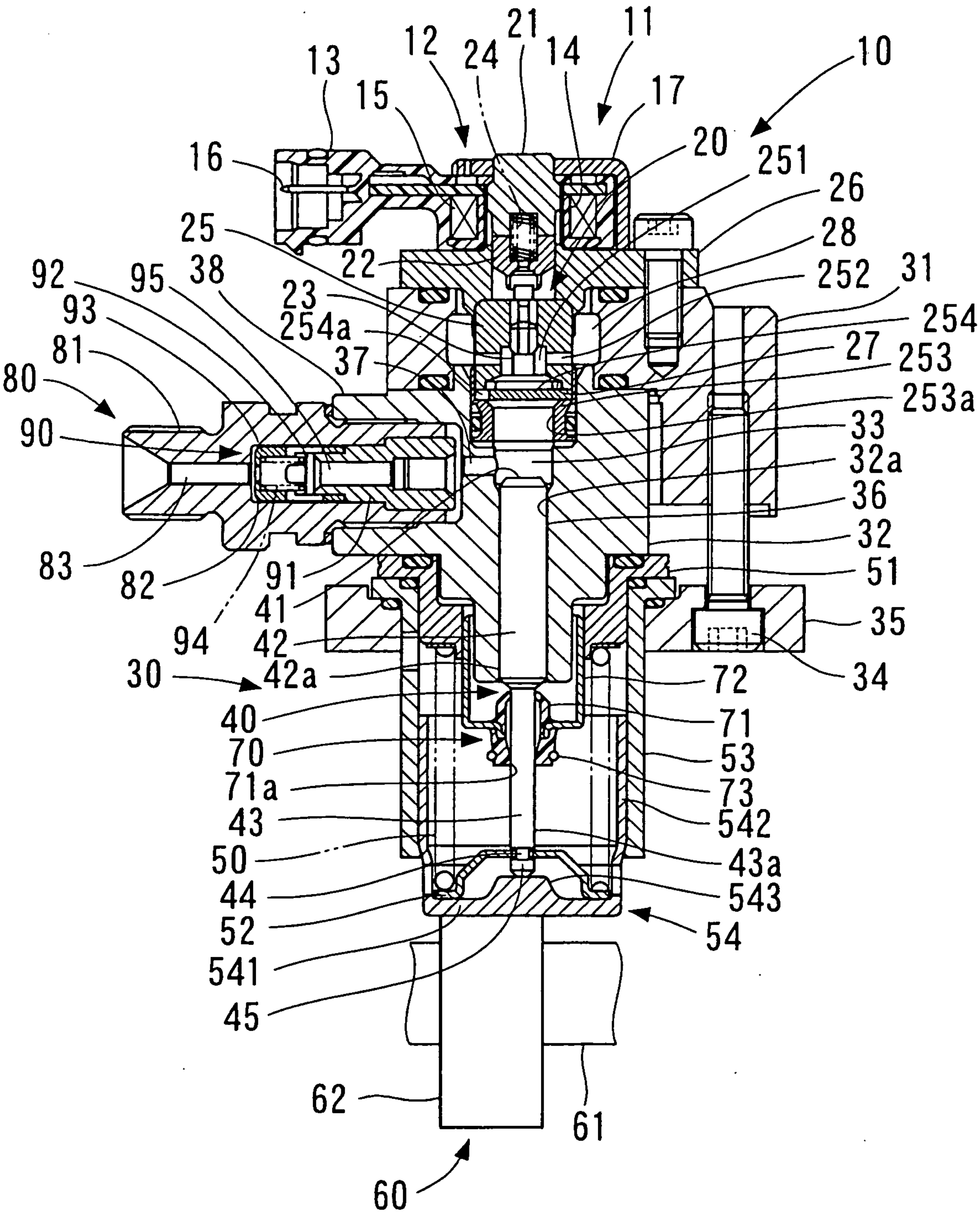
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FIG. 2

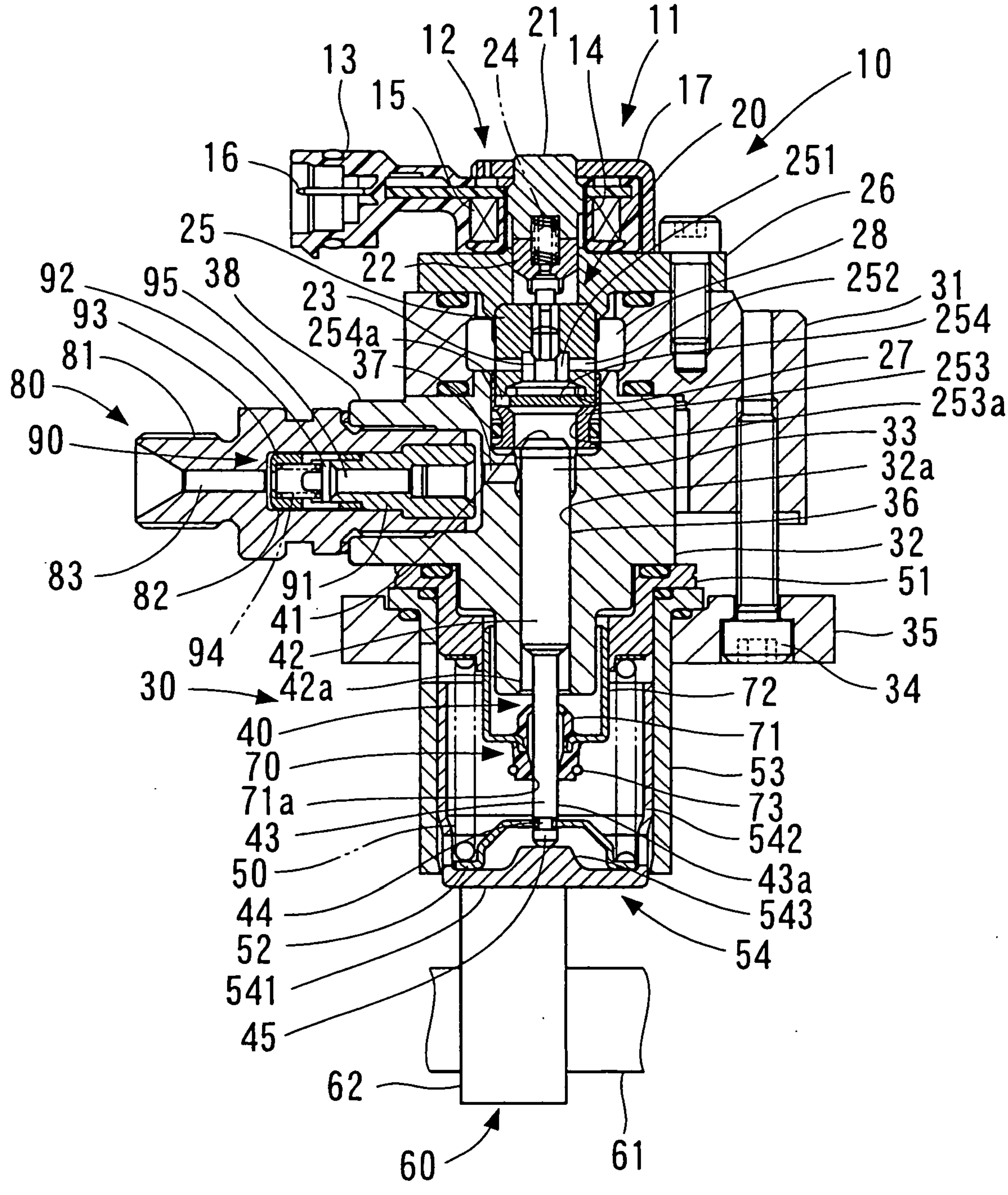
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FIG. 3

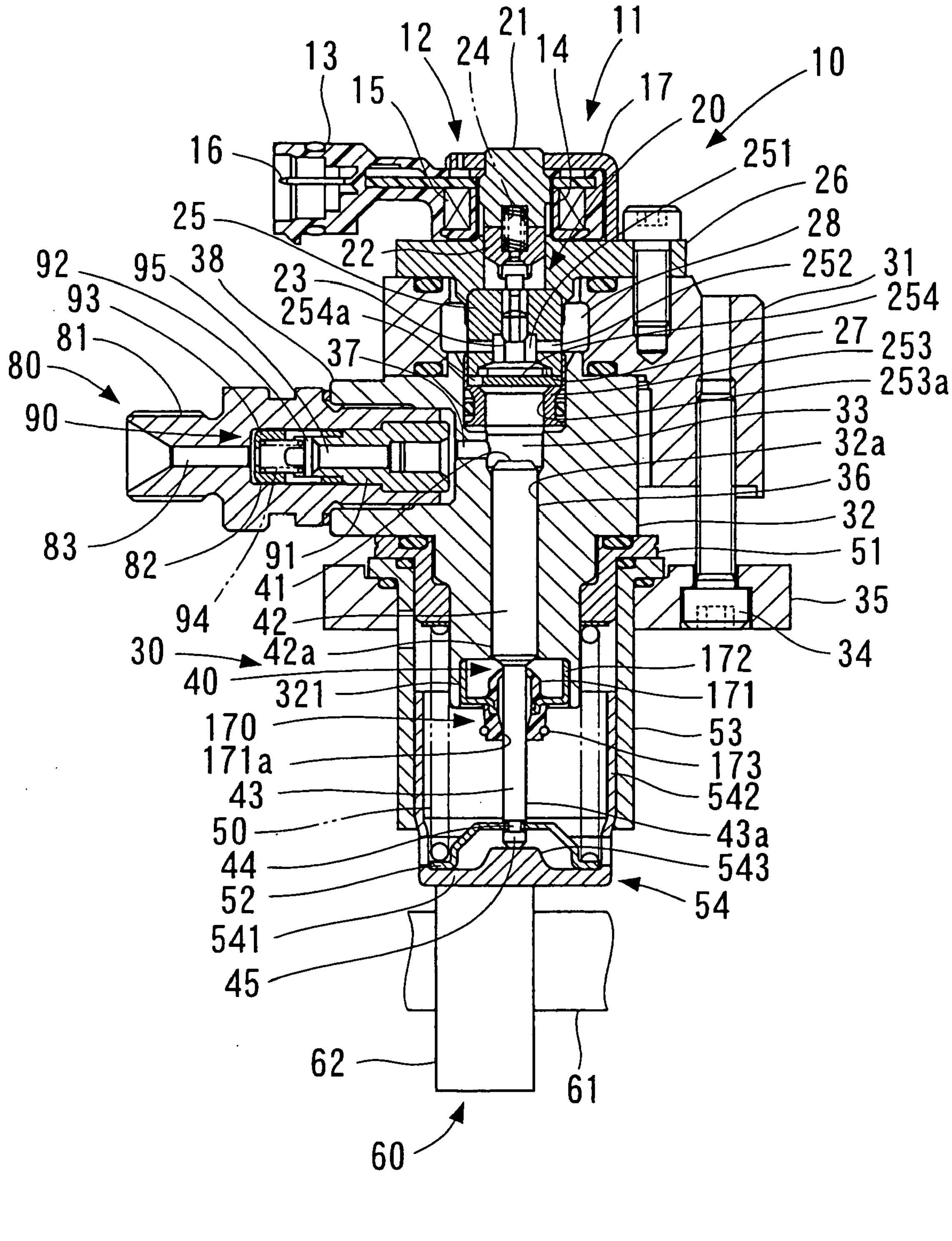
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FIG. 4

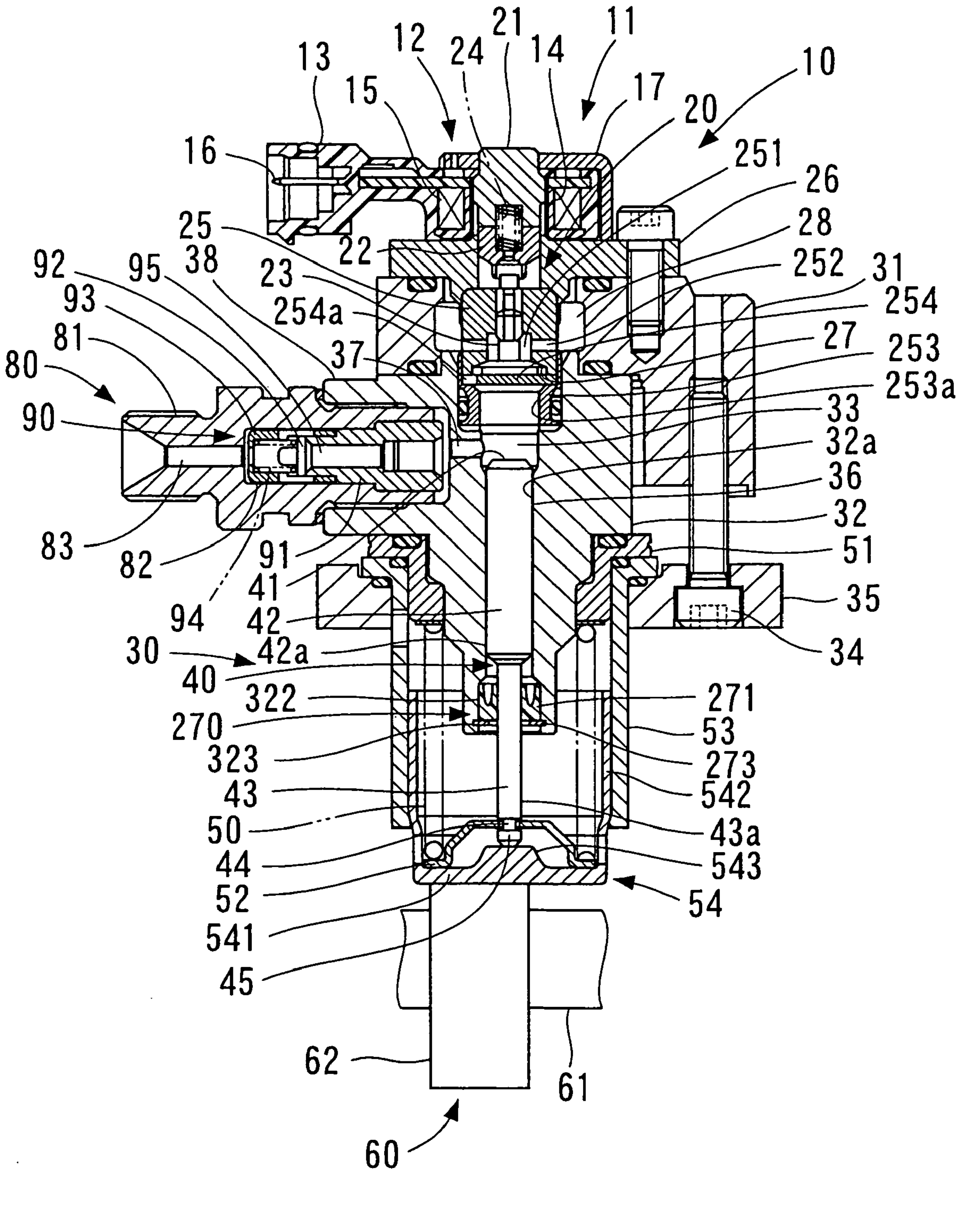
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FIG. 5

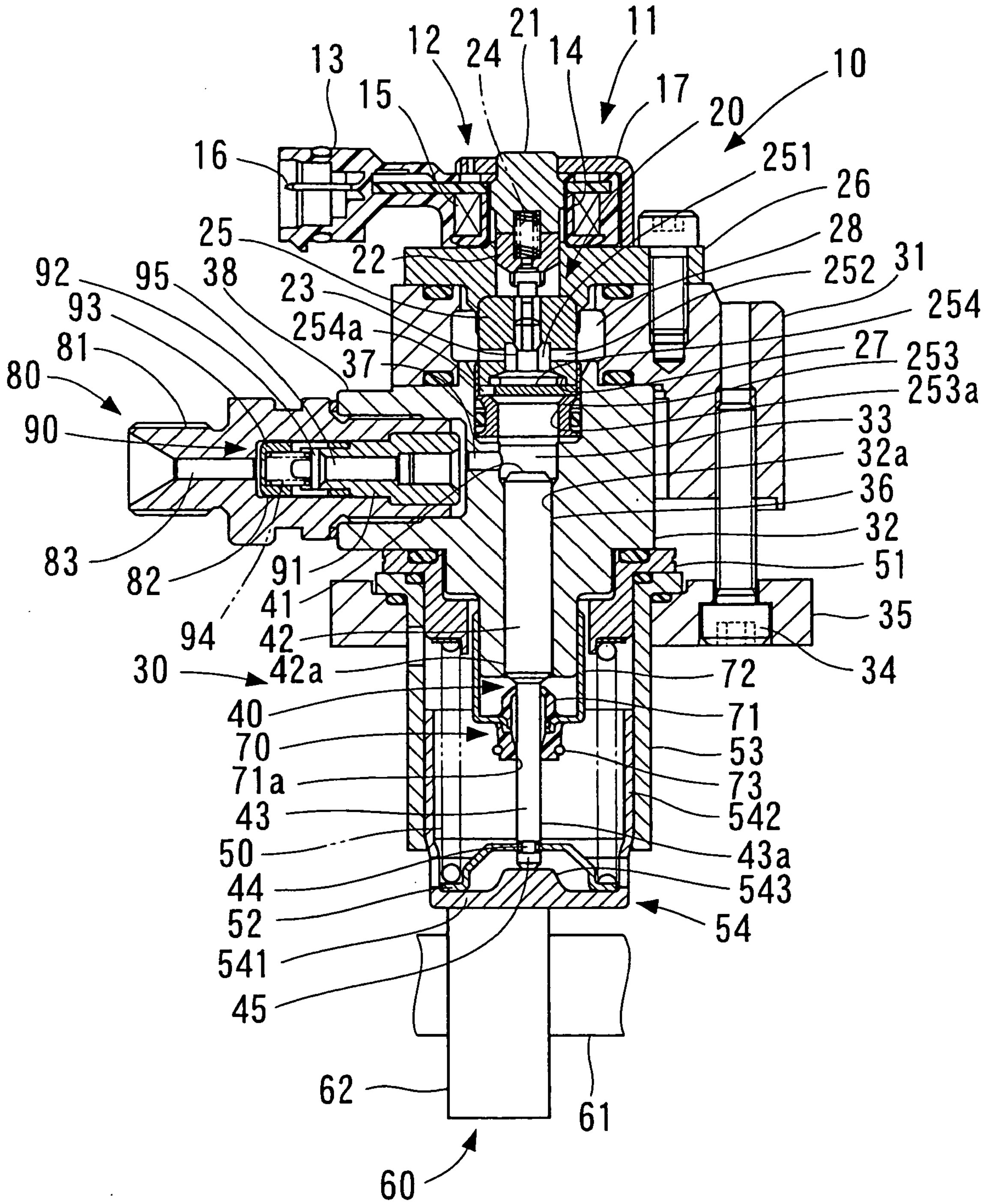

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FIG. 6

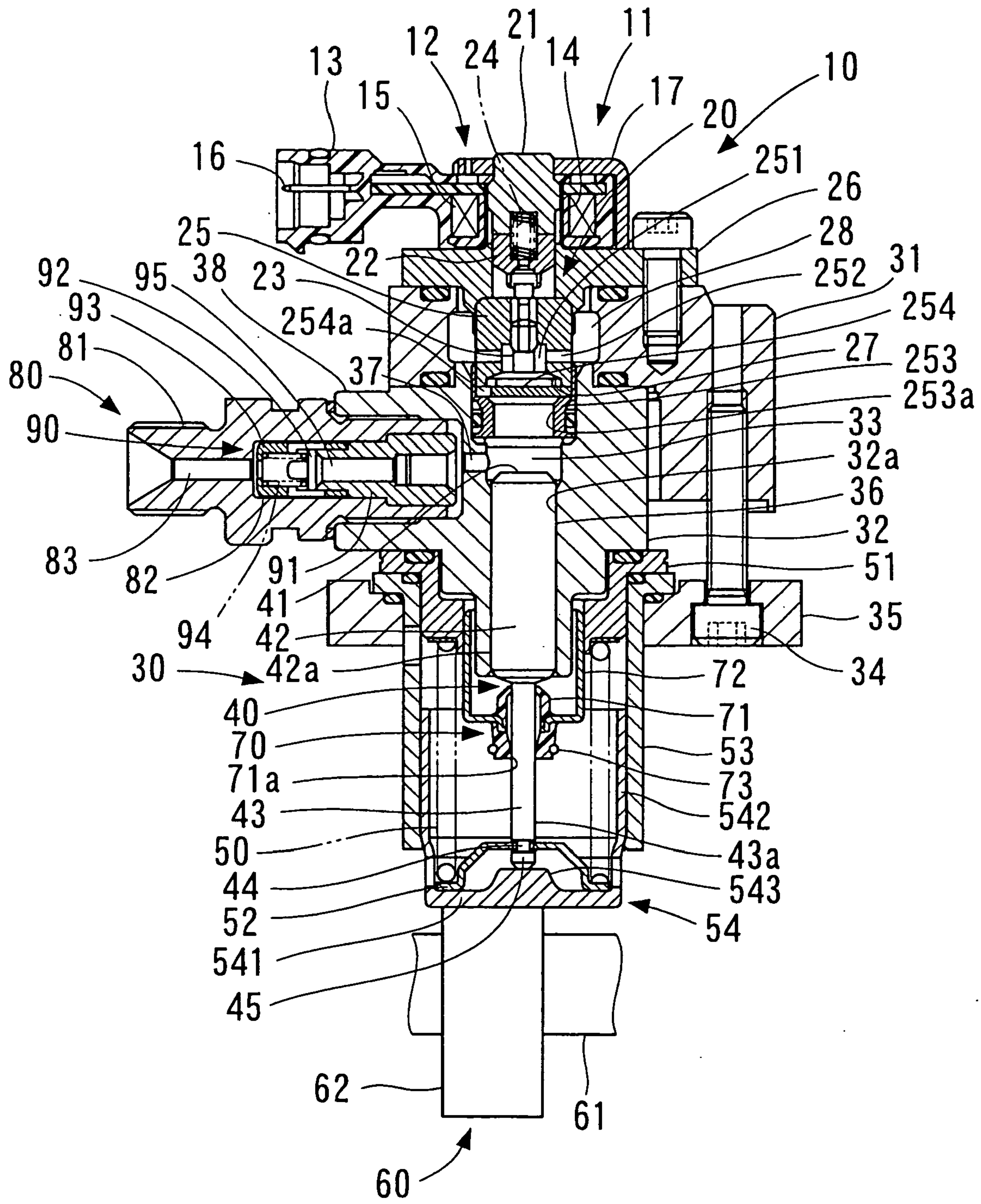
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FIG. 7

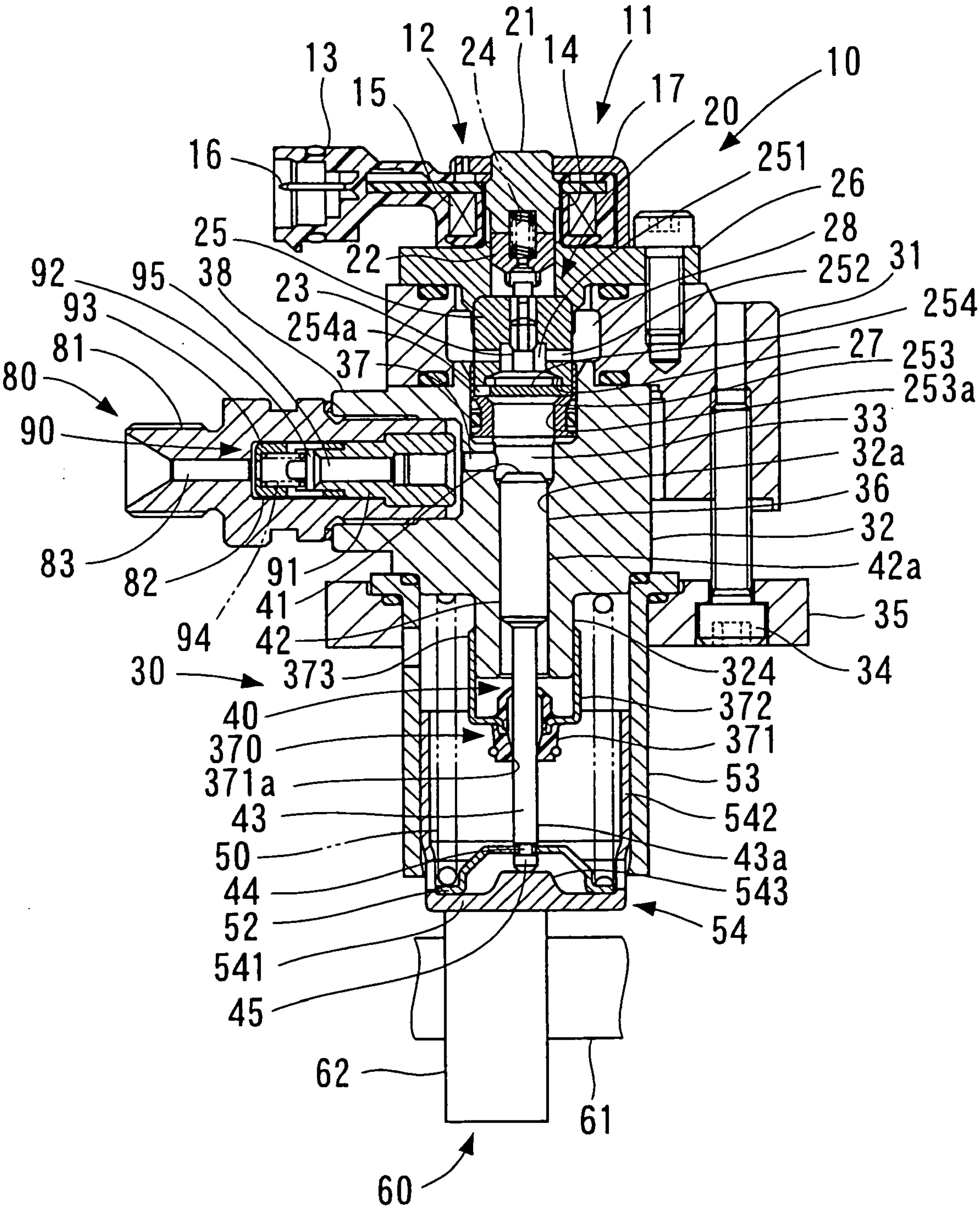
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FIG. 8

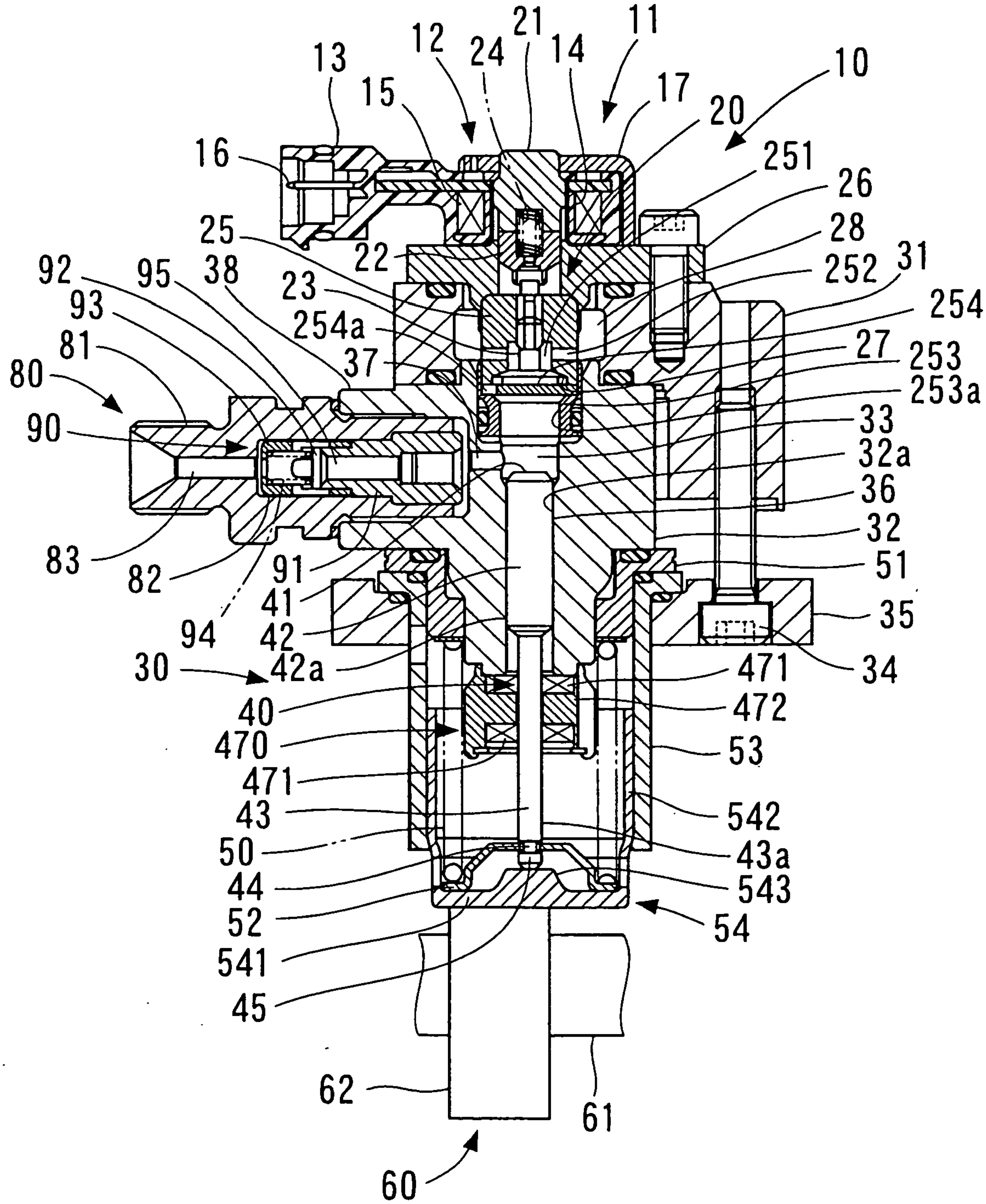
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FIG. 9

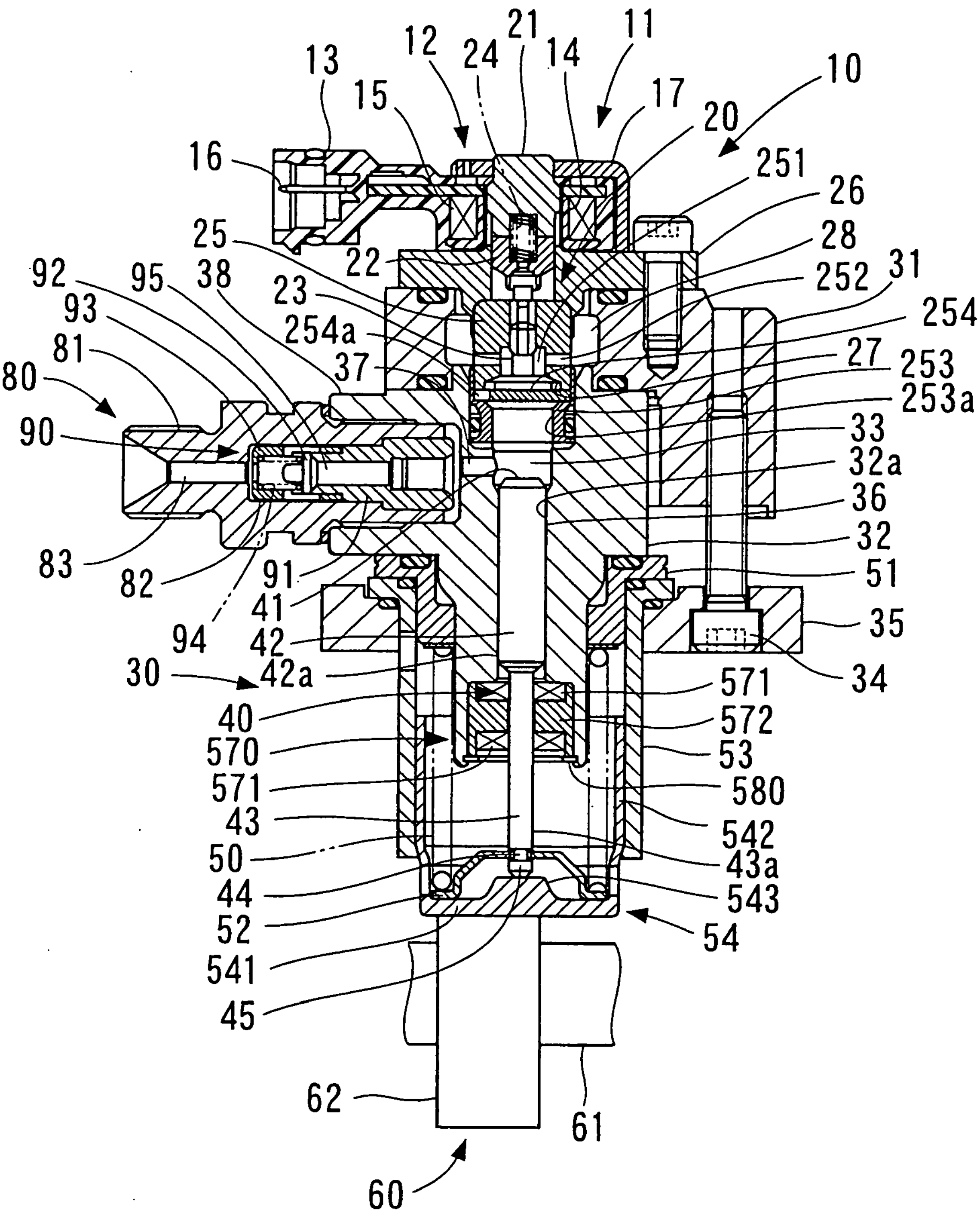
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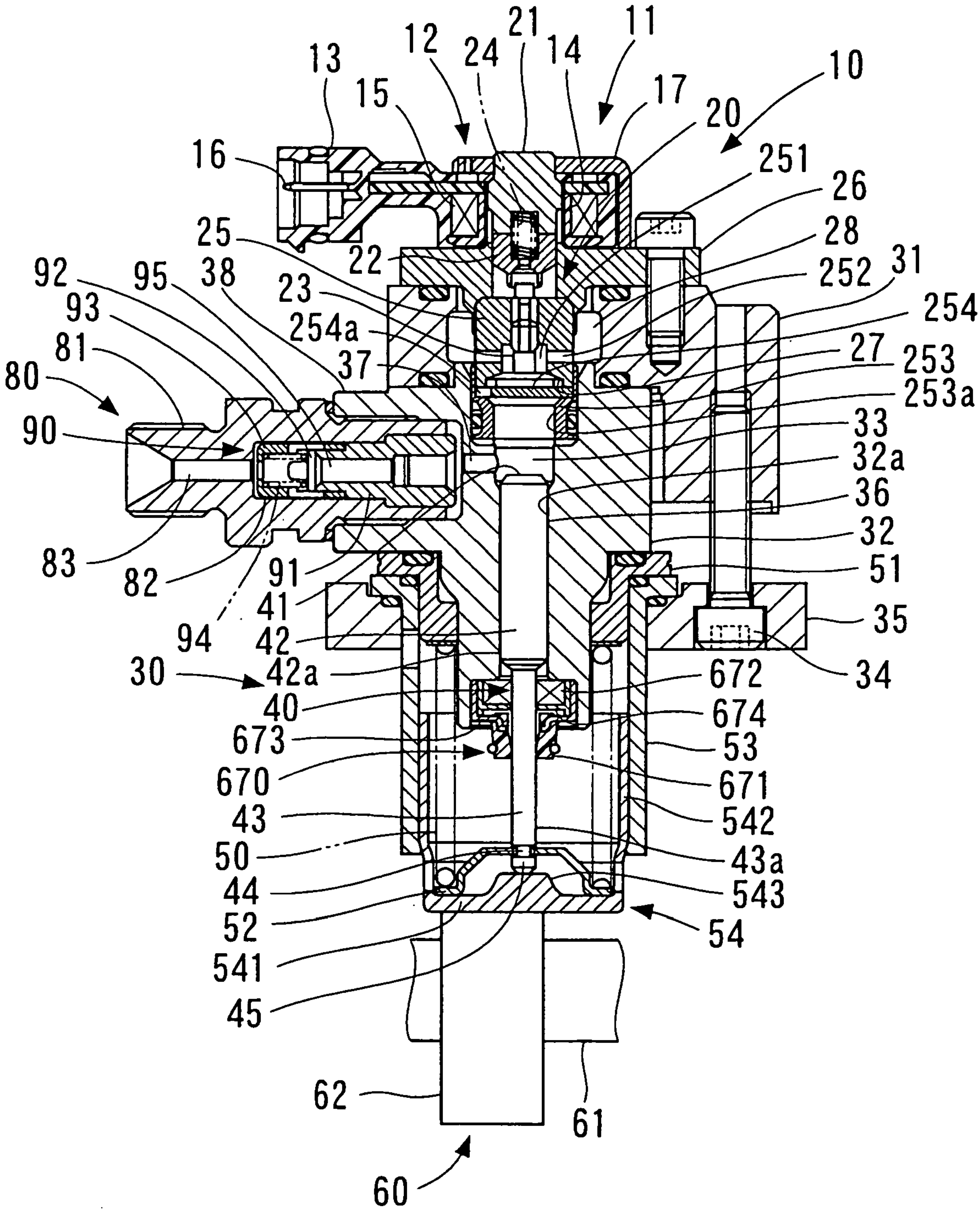
FIG. 10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EUROPEAN SEARCH REPORT

Application Number
EP 05 02 2826

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
The Hague	27 January 2006	Kolby, L

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