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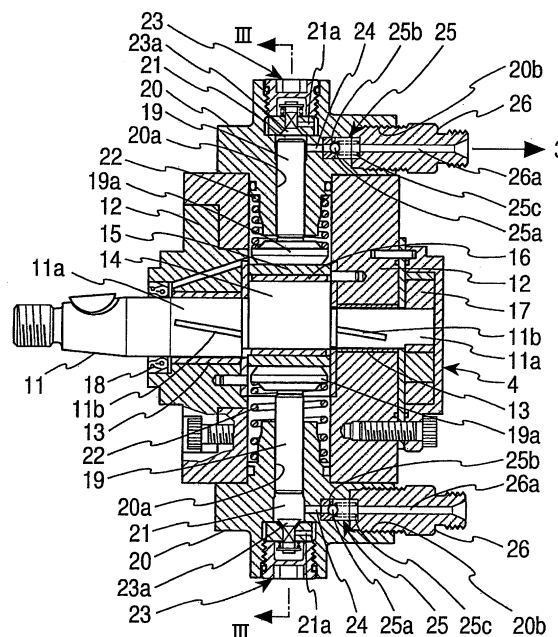
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(54) High-pressure fuel supply pump

(57) A high-pressure fuel supply pump (4) has a camshaft (11), a cam (14), a housing (12, 20) and a plunger (19). The cam is provided on the camshaft such that a central axis of the cam is deviated from a central axis of the camshaft. The cam rotates with the camshaft. The housing is formed with a cam chamber (27) for accommodating the camshaft and with a fuel pressurization chamber (21) for pressurizing fuel. The plunger recipro-

cates due to the rotation of the cam to pressurize and to pressure-feed the fuel suctioned into the fuel pressurization chamber. The camshaft is rotatably held by bearings (13) formed in the housing at sliding faces (11a) formed on the camshaft on both sides of the cam. The fuel supply pump is formed with a lubricating passage (11b) for introducing the fuel in the cam chamber into a space between at least one of the sliding faces and the bearing.

FIG. 2



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Description

[0001] The present invention relates to a high-pressure fuel supply pump that pressurizes fuel by reciprocating a plunger with rotation of a cam provided on a camshaft. Specifically, the present invention is suitably applied to a high-pressure fuel supply pump of a common rail (high-pressure fuel accumulation pipe) fuel injection device of a diesel engine.

[0002] A common rail fuel injection device of a diesel engine draws fuel from a fuel tank with a feed pump and pressurizes the drawn fuel with a high-pressure fuel supply pump. The fuel injection device pressure-feeds the high-pressure fuel into a common rail with the high-pressure fuel supply pump. The high-pressure fuel pressure-fed into the common rail is injected into a cylinder of the engine from an injector. A known high-pressure fuel supply pump is structured such that the central axis of the cam is deviated from the central axis of the camshaft as described in JP-A-2002-310039, for example. The fuel supply pump reciprocates a plunger with the use of a cam ring revolving in accordance with rotation of the cam. Thus, the fuel pump pressurizes the fuel in a pressurization chamber and pressure-feeds the fuel. JP-A-2002-310039 describes a technology for reducing abrasion or seizing of the cam and the cam ring by forming a concave portion on an outer peripheral wall of the cam in an area, to which a reaction force of the fuel pressure-feeding operation of the plunger is not applied, for introducing a lubricating fluid (fuel) in the cam chamber to a space between the cam and the cam ring.

[0003] The camshaft as a component of the high-pressure fuel supply pump has sliding faces that are provided on both sides of the cam and slide on bearing metals attached to a housing. Problems such as abrasion or seizing of the sliding faces of the camshaft can be caused by an increase in a bearing stress at the sliding faces.

[0004] It is an object of the present invention to provide a high-pressure fuel supply pump capable of inhibiting abrasion or seizing by reducing friction at a sliding face of a camshaft.

[0005] According to an aspect of the present invention, a high-pressure fuel supply pump has a camshaft, a cam, a housing and a plunger. The cam is provided on the camshaft such that a central axis of the cam is deviated from a central axis of the camshaft. The cam rotates with the camshaft. The housing is formed with a cam chamber for accommodating the camshaft and with a fuel pressurization chamber for pressurizing fuel. The plunger reciprocates due to the rotation of the cam to pressurize and to pressure-feed the fuel suctioned into the fuel pressurization chamber. The camshaft is rotatably held by a bearing formed in the housing at sliding faces formed on the camshaft on both sides of the cam. The fuel supply pump is formed with a lubricating passage for introducing the fuel in the cam chamber into a space between at least one of the sliding faces and the bearing.

[0006] With this structure, the fuel in the cam chamber

as a lubricating fluid can be introduced into the space between the sliding face of the camshaft and the bearing through the lubricating passage. As a result, friction between the sliding face of the camshaft and the bearing is reduced, and abrasion or seizing can be inhibited.

[0007] Features and advantages of embodiments will be appreciated, as well as methods of operation and the function of the related parts, from a study of the following detailed description, the appended claims, and the drawings, all of which form a part of this application. In the drawings:

Fig. 1 is a schematic diagram showing a common rail fuel injection system of a diesel engine having a high-pressure fuel supply pump according to a first example embodiment of the present invention;

Fig. 2 is a longitudinal sectional view showing the high-pressure fuel supply pump according to the Fig. 1 embodiment;

Fig. 3 is a sectional diagram showing the high-pressure fuel supply pump of Fig. 2 taken along the line III-III;

Fig. 4 is a diagram showing a camshaft and a cam according to the Fig. 1 embodiment;

Fig. 5(a) is a view showing the camshaft according to the Fig. 1 embodiment;

Fig. 5(b) is a sectional view showing the camshaft of Fig. 5(a) taken along the line VB-VB;

Fig. 6(a) is a view showing a camshaft according to a second example embodiment of the present invention;

Fig. 6(b) is a sectional view showing the camshaft of Fig. 6(a) taken along the line VIB-VIB;

Fig. 7(a) is a view showing a camshaft according to a third example embodiment of the present invention;

Fig. 7(b) is a sectional view showing the camshaft of Fig. 7(a) taken along the line VIIIB-VIIIB;

Fig. 8(a) is a view showing a camshaft according to a fourth example embodiment of the present invention;

Fig. 8(b) is a sectional view showing the camshaft of Fig. 8(a) taken along the line VIIIIB-VIIIIB;

Fig. 9(a) is a view showing a camshaft according to a fifth example embodiment of the present invention;

Fig. 9(b) is a sectional view showing the camshaft of Fig. 9(a) taken along the line IXB-IXB;

Fig. 10(a) is a view showing a camshaft according to a sixth example embodiment of the present invention;

Fig. 10(b) is a sectional view showing the camshaft of Fig. 10(a) taken along the line XB-XB;

Fig. 11 (a) is a view showing a camshaft according to a seventh example embodiment of the present invention;

Fig. 11 (b) is a sectional view showing the camshaft of Fig. 11 (a) taken along the line XIB-XIB;

Fig. 12(a) is a view showing a camshaft according

to an eighth example embodiment of the present invention;

Fig. 12(b) is a sectional view showing the camshaft of Fig. 12(a) taken along the line XIIIB-XIIB;

Fig. 13(a) is a view showing a camshaft according to a ninth example embodiment of the present invention;

Fig. 13(b) is a sectional view showing the camshaft of Fig. 13(a) taken along the line XIIIB-XIIB;

Fig. 14(a) is a view showing a camshaft according to a tenth example embodiment of the present invention;

Fig. 14(b) is a sectional view showing the camshaft of Fig. 14(a) taken along the line XIVB-XIVB;

Fig. 15(a) is a view showing a camshaft according to an eleventh example embodiment of the present invention;

Fig. 15(b) is a sectional view showing the camshaft of Fig. 15(a) taken along the line XVB-XVB;

Fig. 16(a) is a view showing a camshaft according to a twelfth example embodiment of the present invention;

Fig. 16(b) is a sectional view showing the camshaft of Fig. 16(a) taken along the line XVIB-XVIB;

Fig. 16(c) is a bottom view showing the camshaft according to the Fig. 16(a) embodiment;

Fig. 17(a) is a view showing a camshaft according to a thirteenth example embodiment of the present invention;

Fig. 17(b) is a sectional view showing the camshaft of Fig. 17(a) taken along the line XVIIB-XVIIB;

Fig. 17(c) is a bottom view showing the camshaft according to the Fig. 17(a) embodiment;

Fig. 18(a) is a view showing a camshaft according to a fourteenth example embodiment of the present invention;

Fig. 18(b) is a sectional view showing the camshaft of Fig. 18(a) taken along the line XVIIIB-XVIIIB;

Fig. 18(c) is a bottom view showing the camshaft according to the Fig. 18(a) embodiment;

Fig. 19(a) is a view showing a camshaft according to a fifteenth example embodiment of the present invention;

Fig. 19(b) is a sectional view showing the camshaft of Fig. 19(a) taken along the line XIXB-XIXB;

Fig. 19(c) is a bottom view showing the camshaft according to the Fig. 19(a) embodiment;

Fig. 20(a) is a view showing a camshaft according to a sixteenth example embodiment of the present invention;

Fig. 20(b) is a sectional view showing the camshaft of Fig. 20(a) taken along the line XXB-XXB;

Fig. 20(c) is a bottom view showing the camshaft according to the Fig. 20(a) embodiment;

Fig. 21 (a) is a view showing a camshaft according to a seventeenth example embodiment of the present invention;

Fig. 21 (b) is a sectional view showing the camshaft

of Fig. 21 (a) taken along the line XXIB-XXIB; and
Fig. 21(c) is a bottom view showing the camshaft according to the Fig. 21 (a) embodiment.

5 **[0008]** Referring to Fig. 1, a common rail fuel injection system of a vehicular diesel engine 1 having a high-pressure fuel supply pump 4 according to a first example embodiment of the present invention is illustrated. The four-cylinder engine 1 has injectors 2 mounted to respective
10 cylinders. Each injector 2 injects fuel when the injector 2 opens. The fuel is supplied from a common rail 3, which is common to the cylinders, to the injectors 2. The high-pressure fuel supply pump 4 pressurizes the fuel drawn from a fuel tank 5 to high pressure and supplies the fuel
15 to the common rail 3. The common rail 3 accumulates and stores the high-pressure fuel. The fuel pressure in the common rail 3 defines injection pressure of the injectors 2. An electronic control unit (ECU) 6 as a controller of the high-pressure fuel supply pump 4 controls the high-pressure fuel supply pump 4 to regulate the fuel pressure in the common rail 3.

[0009] The ECU 6 controls various parts of the engine 1 such as the injectors 2 or the high-pressure fuel supply pump 4. In order to control the various parts of the engine 1, the ECU 6 reads in output signals of sensors attached to the various parts of the engine 1 for sensing operation
25 states of the engine 1. A pressure sensor 7 for sensing the pressure in the common rail 3 is attached to the common rail 3. A rotation speed sensor 8 as a rotation cycle sensor is provided for sensing rotation of a crankshaft that outputs power of the engine 1. The ECU 6 maintains suitable operation of the engine 1 by controlling the injectors 2 and the high-pressure fuel supply pump 4 based on the signals of the sensors 7, 8 and the like.

35 **[0010]** Fig. 2 is a longitudinal sectional view showing the high-pressure fuel supply pump 4 according to the present embodiment. Fig. 3 is a sectional view showing the high-pressure fuel supply pump 4 of Fig. 2 taken along the line III-III. A camshaft 11 is rotated by the engine 1.
40 The camshaft 11 is accommodated in two housings 12 made of an aluminum and cylinder blocks 20 as housings. The camshaft 11 is held by bearing metals as bearings 13 provided in the two housings 12 at sliding faces 11a such that the camshaft 11 can rotate in a sliding manner.
45 A cam 14 has a circular profile and is integrally formed with the camshaft 11. The center of the cam 14 is deviated from the rotation center of the camshaft 11. The cam 14 slidably contacts a cam bush 16, which is fitted into a cam ring 15, at a cam sliding face 14a. The cam 14 rotates
50 around the rotation central axis of the camshaft 11. The two sliding faces 11a are formed on the camshaft 11 on both sides of the cam 14. The cam ring 15 does not rotate but evolves around the rotation central axis of the camshaft 11 due to the rotation of the cam 14.

55 **[0011]** A trochoid feed pump 17 is driven by the camshaft 11. The feed pump 17 draws the fuel from the fuel tank 5 and pressure-feeds the fuel to a suction metering valve (not shown). The feed pump 17 is incorporated in

the high-pressure fuel supply pump 4. The feed pump 17 communicates with a cam chamber 27 surrounded and formed by the two housings 12 and the two cylinder blocks 20, a clearance between the two sliding faces 11 a of the camshaft 11 and the bearings 13 and a clearance between the cam sliding face 14a of the cam 14 and the cam bush 16 as a bearing. Thus, these clearances are invariably filled with the fuel so that the fuel exerts a lubricating effect as a lubricating fluid. An oil seal 18 prevents flowing out of the lubricating fluid supplied from the feed pump 17 to the clearance between the sliding faces 11a and the bearings 13. The cam 14 and the cam ring 15 rotate and revolve in the cam chamber 27.

[0012] The plunger 19 reciprocates in a cylinder 20a formed in the iron cylinder block 20 defining the housing. A plunger head 19a formed integrally with a lower end of the plunger 19 (on a side closer to the center of the camshaft 11) slidably contacts the cam ring 15 due to a resilient force of a spring 22. The cam ring 15 pushes up the plunger 19 through its revolving movement.

[0013] A fuel pressurization chamber 21 is formed in the cylinder 20a. The fuel is suctioned from the feed pump 17 through the fuel metering valve and a fuel inlet passage 21 a and is pressurized in the fuel pressurization chamber 21 to high pressure through the reciprocation of the plunger 19. A fuel suction valve 23 has a check valve 23a. The check valve 23a prevents a backflow of the fuel into the fuel inlet passage 21 a when the fuel is pressurized in the fuel pressurization chamber 21.

[0014] A fuel discharge passage 24 is connected to the fuel pressurization chamber 21. A fuel discharge valve 25 is provided downstream of the fuel discharge passage 24 with respect to the fuel flow. The fuel discharge valve 25 has a ball-shaped valve 25a, a tapered seat 25b, on which the valve 25a can be seated, and a spring 25c for biasing the valve 25a to the tapered seat 25b. The valve 25a is normally seated on the tapered seat 25b. If the pressure of the fuel entering from the fuel discharge passage 24 becomes equal to or higher than the fuel pressure in a fuel passage 26a, the valve 25a separates from the tapered seat 25b. The fuel flows through the fuel passage 26a of a connector 26 screwed to a connection hole 20b of the cylinder block 20 and flows into the common rail 3. The two fuel discharge valves 23 open in turn in each half rotation of the camshaft 11.

[0015] A lubricating passage 11 b is formed on the sliding face 11 a of the camshaft 11 for introducing the lubricating fluid to the sliding face 11a. The lubricating passage 11 b is formed on the sliding face 11 a of the camshaft 11 in an area, to which a reaction force due to the fuel pressure-feeding operation of the plunger 19 is not applied. In this area, the clearance between the sliding face 11a and the bearing metal 13 is large. Accordingly, the lubricating fluid resides in the clearance, so the lubricating fluid can be held in the sliding passage 11 b.

[0016] The area, to which the reaction force is not applied, will be explained in reference to Fig. 4. The cam

14 rotates in accordance with the rotation of the camshaft 11. The cam function starts at a point E and ends at a rising point F as shown in Fig. 4. There is a delay area C of the fuel pressure-feeding operation due to a delay in valve closing of the fuel suction valve 23 and the like. There is a residual area D of the reaction force because the fuel pressure in the fuel pressurization chamber 21 does not decrease sufficiently even after the rising point F. Accordingly, the reaction force is not applied to an area A (approximately a half of the circumference of the camshaft 11) of the sliding face 11a of the camshaft 11 and an area B (approximately a half of the circumference of the cam 14) of the cam 14. Centers of the area A and the area B are slightly deviated from each other but the areas A, B approximately face each other.

[0017] The lubricating passage 11 b is formed in the area A of the sliding face 11 a, to which the reaction force is not applied. Since the pressure applied to the sliding face 11 a by the bearing 13 is uneven, the lubricating passage 11 b should be preferably formed at the substantially center of the area A.

[0018] In the high-pressure fuel supply pump 4 having the above-described structure, the cam 14 rotates due to the rotation of the camshaft 11 and the cam ring 15 revolves due to the rotation of the cam 14. The cam ring 15 moves in a radial direction of the camshaft 11 due to the revolution of the cam ring 15 and pushes up the plunger 19. Thus, the check valve 23a of the fuel suction valve 23 closes and the fuel in the fuel pressurization chamber 21 is pressurized. The pressurized fuel flows into the fuel discharge passage 24. If the pressure of the pressurized fuel exceeds the fuel pressure in the fuel passage 26a, the fuel separates the valve 25a from the tapered seat 25b and is accumulated in the common rail 3 through the fuel passage 26a. The fuel accumulated in the common rail 3 is supplied to the injectors 2. If the camshaft 11 rotates further to enter an area, in which the cam 14 does not exert the cam function, the plunger 19 existing at the rising point due to the revolution of the cam ring 15 descends due to the biasing force of the spring 22 (toward the center of the camshaft 11), and the fuel is suctioned into the fuel pressurization chamber 21 through the fuel inlet passage 21 a and the check valve 23a. Thus, the cycle of one rotation of the camshaft 11 ends. The high-pressure fuel supply pump 4 of the present embodiment is a two-cylinder type. Therefore, the two plungers 19 pressurize and pressure-feed the fuel in turn in each half rotation of the camshaft 11.

[0019] Next, the camshaft 11 of the present embodiment will be described in more detail in reference to Fig. 5. As shown in Fig. 5(a), the cam 14 is formed integrally with the camshaft 11 at approximately the center of the camshaft 11. The camshaft 11 rotates in a direction shown by an arrow mark in Fig. 5(b). The profile of the cam 14 is a circular shape. The central axis of the cam 14 is deviated from the rotation central axis of the camshaft 11 by a predetermined distance. Therefore, the cam 14 rotates around the rotation central axis of the camshaft

11. The diameters of the two sliding faces 11 a are smaller than the diameter of the cam 14. The diameter of one sliding face 11 a on the right hand of Fig. 5(a), to which an inner rotor (not shown) of the feed pump 17 is attached, is smaller than the diameter of the other sliding face 11 a. Since the two sliding faces 11 a have small bearing areas, large bearing stress is applied to the sliding faces 11 a by the reaction force due to the fuel pressure-feeding operation.

[0020] Manufacturing clearance grooves 11c are formed on the camshaft 11 on both sides of the cam 14. The manufacturing clearance grooves 11c are necessary for finish processing of the sliding faces 11a. Improvement (lowering) of surface roughness of the sliding faces 11a is necessary because of the function of the sliding faces 11 a. Therefore, grinding process of the sliding faces 11a is performed. In order to perform the grinding process over the entire width of each sliding face 11 a, a grindstone as a manufacturing tool has to be moved in a range wider than the entire width of the sliding face 11 a. In such a case, the grindstone contacts the end face of the cam 14. In order to avert the contact, the manufacturing clearance groove 11c having a predetermined width is formed. With the manufacturing clearance groove 11c, the grinding process can be performed over the entire width of the sliding face 11a while averting the contact between the grindstone and the end face of the cam 14.

[0021] The lubricating fluid is introduced to the lubricating passages 11 b formed on the two sliding faces 11a to reduce the friction between the sliding faces 11a and the bearings 13. Thus, abrasion and seizing can be inhibited. Since the lubricating passages 11 b are formed on both of the sliding faces 11a, the lubricating effect is exerted over the entire width of the sliding faces 11a. Thus, the present invention can be applied to a large capacity high-pressure fuel supply pump or a multi-cylinder high-pressure fuel supply pump.

[0022] The lubricating passage 11 b extends at a slant with respect to the rotation central axis of the camshaft 11 as shown in Fig. 5(a). By providing the lubricating passage 11 b at a suitable slant, inertia due to fluctuation in the rotation speed of the camshaft 11 is applied to the lubricating fluid in the lubricating passage 11 b. Since the camshaft 11 is driven by the engine 1, the rotation speed of the camshaft 11 fluctuates due to the fluctuation of the rotation speed of the engine 1. Thus, the lubricating fluid is forced to flow along the slanted lubricating passages 11 b. This is a screw effect. As a result, lubricating performance between the sliding faces 11a and the bearings 13 is further improved.

[0023] Each lubricating passage 11 b is a concave portion (groove) having a section in the shape of a cornered character C. The concave portion 11b is formed through a milling process. Process for eliminating burrs is applied to the edge between the concave portion 11b and the sliding face 11 a. An end of the concave portion 11 b opens into and communicates with the manufacturing

clearance groove 11c. The other end is blocked. It is because the state in which the circumference of the camshaft 11 is hermetically blocked by the oil seal 18 cannot be maintained if the other end is also opened.

[0024] Since the lubricating passages 11 b are formed in the shape of the concave portions on the sliding faces 11a of the camshaft 11, the lubricating fluid can be surely held in the concave portions 11b. Thus, the friction can be further reduced. Since the ends of the concave portions 11 b open into and communicate with the manufacturing clearance grooves 11c, the lubricating fluid smoothly flows into the concave portions 11 b through the manufacturing clearance grooves 11 c. Thus, the friction can be further reduced.

[0025] A camshaft 11 according to a second example embodiment of the present invention is shown in Fig. 6. As shown in Fig. 6(a), the camshaft 11 of the second example embodiment is formed with two concave portions 11 b extending along the same slant direction like the first example embodiment. Since the two concave portions 11 b are set at the same slant direction, the machining process of the two concave portions 11 b can be performed by moving the camshaft 11, which is placed as a processed object of the machining process, in only one direction perpendicular to the slant direction of the concave portions 11 b. Thus, the first and second example embodiments can shorten the processing time and reduce the manufacturing cost.

[0026] The slant direction of the concave portions 11 b of the second example embodiment shown in Fig. 6 is different from that of the first example embodiment shown in Fig. 5. In the first example embodiment, the concave portions 11 b extend diagonally right down in Fig. 5(a). In the second example embodiment, the concave portions 11 b extend diagonally right up in Fig. 6(a). The direction of the slant is arbitrarily chosen in accordance with restrictions of the facility for performing the machining process of the concave portions 11 b.

[0027] Fig. 7 shows a camshaft 11 according to a third example embodiment of the present invention, and Fig. 8 shows a camshaft 11 according to a fourth example embodiment of the present invention. The camshaft 11 of the third or fourth example embodiment is formed with two concave portions 11 b extending in opposite directions substantially symmetrically across the cam 14. Since the slant directions of the two concave portions 11 b are set symmetrically across the cam 14, the ends of the concave portions 11 b can be opened on the same horizontal line at two positions distant from the central line of the camshaft 11 by a predetermined distance into the manufacturing clearance grooves 11c as shown in Fig. 7(a) or 8(a). Thus, the lubrication of the sliding faces 11a at the two positions can be performed in the same state.

[0028] The slant directions (positional relationship) of the concave portions 11 b of the third example embodiment shown in Fig. 7 are different from those of the fourth example embodiment shown in Fig. 8. The slant direc-

tions may be chosen arbitrarily in accordance with the restrictions of the facility for performing the machining process of the concave portions 11 b like the first and second example embodiments.

[0029] Figs. 9 to 12 show camshafts 11 according to fifth to eighth example embodiments of the present invention respectively. The camshaft 11 of each one of the fifth to eighth example embodiments is formed with a concave portion 11 b on either one of two sliding faces 11 a. A common structure of the camshaft 11 is the same as that of each one of the first to fourth example embodiments. A sufficient lubricating effect can be obtained even though the concave portion 11 b is formed at only one position of the sliding face 11a depending on, e.g., a capacity or the number of the cylinder(s) of the high-pressure fuel supply pump. The number of the groove(s) may be arbitrarily selected in accordance with the capacity or the number of the cylinder(s) of the high-pressure fuel supply pump.

[0030] The camshaft 11 of the fifth example embodiment shown in Fig. 9 or the sixth example embodiment shown in Fig. 10 is formed with the concave portion 11 b on the sliding face 11a on the left hand in Fig. 9(a) or 10(a). An end of the concave portion 11 b opens into the manufacturing clearance groove 11c, and the other end is blocked for the same reason as in the first to fourth example embodiments. The slant direction (positional relationship) of the concave portion 11 b is different between the fifth and sixth example embodiments shown in Figs. 9 and 10. The slant direction of the concave portion 11 b may be arbitrarily selected in accordance with the restrictions of the facility for performing the machining process of the concave portion 11 b as in the first and second example embodiments.

[0031] The camshaft 11 according to the seventh example embodiment shown in Fig. 11 or the eighth example embodiment shown in Fig. 12 is formed with the concave portion 11 b on the sliding face 11a on the right hand in Fig. 11 (a) or 12(a) having the smallest diameter. The concave portion 11 b formed on the sliding face 11a, which has the smallest diameter and receives large bearing stress, is effective in inhibition of the abrasion and seizing. An end of the concave portion 11 b opens into the manufacturing clearance groove 11c, and the other end is blocked for the same reason as the first to fourth example embodiments. The slant direction of the concave portion 11 b differs between the seventh and eighth example embodiments. The slant direction may be arbitrarily selected in accordance with the restrictions of the facility for performing the machining process of the concave portion 11 b.

[0032] Figs. 13, 14 and 15 show the camshafts 11 of the ninth, tenth and eleventh example embodiments of the present invention respectively. A common structure of the camshaft 11 is similar to that of the camshaft 11 according to each one of the first to fourth example embodiments. A chamfer 11b as a concave portion is formed by partly cutting the outer periphery of at least one of the

sliding faces 11a along a horizontal direction. Thus, at least one lubricating passage is formed on the camshaft 11 as shown in Fig. 13, 14 or 15. The lubricating passage extends along the rotation central axis of the camshaft 11. An end of the chamfer 11 b opens into the manufacturing clearance groove 11c and the other end is blocked. It is because the state in which the oil seal 18 hermetically blocks the circumference of the camshaft 11 cannot be maintained if the other end is also opened. The chamfer 11b is formed by the milling process or cutting process. Process for eliminating burrs is applied to an edge between the chamfer 11 b and the sliding face 11a.

[0033] Since the lubricating passage in the shape of the chamfer 11 b is formed on the sliding face 11a of the camshaft 11, the lubricating fluid can be surely held at the chamfer 11b. Thus, the friction can be further reduced. The chamfer 11 b is formed through simple process for chamfering a part of the outer periphery of the sliding face 11a. Accordingly, the machining process is easy and the manufacturing cost can be reduced compared to the process for forming the concave portion such as the groove. Since the end of the chamfer 11 b opens into and communicates with the manufacturing clearance groove 11c, the lubricating fluid smoothly flows into the chamfer 11 b through the manufacturing clearance groove 11c. Thus, the friction can be further reduced.

[0034] In the ninth example embodiment shown in Fig. 13, the chamfers 11 b are formed on both of the sliding faces 11a on both sides of the cam 14. Since the chamfers 11 b are formed on both of the sliding faces 11a, the lubricating effect can be exerted throughout the entire width of the sliding faces 11 a. Thus, the present invention can be applied to the large capacity high-pressure fuel supply pump or the multi-cylinder high-pressure fuel supply pump.

[0035] In the tenth example embodiment shown in Fig. 14, the chamfer 11 b is formed only on the sliding face 11 on the left hand of Fig. 14(a). In the eleventh example embodiment shown in Fig. 15, the chamfer 11 b is formed only on the sliding face 11 a on the right hand of Fig. 15 (a). Even only one chamfer 11 b can exert a sufficient lubricating effect, depending on the capacity or the number of the cylinder(s) of the high-pressure fuel supply pump. The number of the chamfer(s) may be selected in accordance with the capacity or the number of the cylinder(s) of the high-pressure fuel supply pump. The chamfer 11 b formed on the sliding face 11 a on the right hand of Fig. 15(a) is effective in the inhibition of the abrasion and seizing of the sliding face 11 a, which has the smallest diameter and receives the large bearing stress.

[0036] Figs. 16, 17 and 18 show the camshafts 11 according to the twelfth, thirteenth and fourteenth example embodiments of the present invention respectively. The camshaft 11 according to the twelfth, thirteenth or fourteenth example embodiment is formed with a lubricating passage on the sliding face 14a of the cam 14 sliding on the bush 16 in the area, to which the reaction force of the fuel pressure-feeding operation is not applied, in addition

to the lubricating passage 11 b formed on the camshaft 11 according to the first example embodiment shown in Fig. 5. The area, to which the reaction force of the fuel pressure-feeding operation of the cam 14 is not applied, is the area B shown in Fig. 4. The common structure of the camshaft 11 is the same as the camshaft 11 of each one of the above-described embodiments.

[0037] Thus, lubrication of all of the sliding faces 11 a, 14a of the camshaft 11 is improved by forming the lubricating passages 11 b, 14b on the sliding faces 11 a of the camshaft 11 and the sliding face 14a of the cam 14. Thus, the present invention can be applied to a large capacity multi-cylinder high-pressure fuel supply pump.

[0038] The camshaft 11 according to the twelfth example embodiment shown in Fig. 16 is formed with a chamfer 14b as a lubricating passage on the sliding face 14a of the cam 14 sliding on the cam bush 16. The chamfer 14b extends along the rotation axis of the cam 14 and opens on both ends of the cam 14. The machining process of the chamfer 14b is the same as that of the ninth, tenth or eleventh embodiment shown in Fig. 13, 14 or 15.

[0039] The camshaft 11 according to the thirteenth or fourteenth example embodiment shown in Fig. 17 or 18 is formed with a concave portion 14b as a lubricating passage on the sliding face 14a of the cam 14 sliding on the cam bush 16. The concave portion 14b is formed at a slant with respect to the rotation axis of the cam 14 and opens at the both ends of the cam 14. The machining process of the concave portion 14b is the same as that of the first to fourth example embodiments shown in Figs. 5 to 8.

[0040] The slant direction (positional relationship) of the concave portion 14b differs between the thirteenth and fourteenth example embodiments shown in Figs. 17 and 18. The slant direction may be arbitrarily selected in accordance with the restrictions of the facility for performing the machining process of the concave portion 14b.

[0041] Figs. 19, 20 and 21 show the camshafts 11 according to fifteenth, sixteenth and seventeenth example embodiments of the present invention respectively. The camshaft 11 of the fifteenth, sixteenth or seventeenth example embodiments is formed with a lubricating passage on the sliding face 14a of the cam 14 sliding on the cam bush 16 in an area, to which the reaction force of the fuel pressure-feeding operation is not applied, in addition to the lubricating passage 11 b formed on the camshaft 11 according to the ninth example embodiment shown in Fig. 13. The area, to which the reaction force of the fuel pressure-feeding operation of the cam 14 is not applied, is the area B shown in Fig. 4. The common structure of the camshaft 11 is the same as that of each one of the above-described embodiments.

[0042] The lubrication of all the sliding faces 11 a, 14a of the camshaft 11 is improved by forming the lubricating passages 11 b, 14b on the sliding face 11 a of the camshaft 11 and the sliding face 14a of the cam 14. Therefore, the present invention can be applied to a large capacity multi-cylinder high-pressure fuel supply pump.

[0043] The camshaft 11 according to the fifteenth example embodiment shown in Fig. 19 is formed with a chamfer 14b as a lubricating passage on the sliding face 14a of the cam 14 sliding on the cam bush 16. The chamfer 14b extends along the rotation central axis of the cam 14 and opens at both ends of the cam 14. The machining process of the chamfer 14b is similar to that of the ninth, tenth or eleventh embodiment shown in Fig. 13, 14 or 15.

[0044] The camshaft 11 according to the sixteenth or seventeenth example embodiment shown in Fig. 20 or 21 is formed with the concave portion 14b as the lubricating passage on the sliding face 14a of the cam 14 sliding on the bush 16. The concave portion 14b is formed at a slant with respect to the rotation central axis of the cam 14 and opens at the both ends of the cam 14. The machining process of the concave portion 14b is similar to that of the first to fourth example embodiments shown in Figs. 5 to 8.

[0045] The slant direction of the concave portion 14b is different between the sixteenth and seventeenth example embodiments shown in Figs. 20 and 21. The slant direction may be arbitrarily selected in accordance with the restrictions of the facility for performing the machining process of the concave portion 14b.

[0046] In the above-described embodiments, the lubricating passage is formed on the sliding face of the camshaft or the sliding face of the cam. Alternatively, the lubricating passage may be formed on the bearing of the housing, more preferably, on the bearing in the area, to which the reaction force of the fuel pressure-feeding operation of the plunger is not applied. Even in this case, similar effects are obtained. In the above-described embodiments, the present invention is applied to the high-pressure fuel supply pump used in the common rail fuel injection device of the vehicular diesel engine. Alternatively, the present invention may be applied to a high-pressure fuel supply pump used in a fuel injection device of a gasoline engine or a high-pressure fuel supply pump used in a device other than the vehicle.

[0047] The present invention should not be limited to the disclosed embodiments, but may be implemented in many other ways without departing from the scope of the invention, as defined by the appended claims.

[0048] A high-pressure fuel supply pump (4) has a camshaft (11), a cam (14), a housing (12, 20) and a plunger (19). The cam is provided on the camshaft such that a central axis of the cam is deviated from a central axis of the camshaft. The cam rotates with the camshaft. The housing is formed with a cam chamber (27) for accommodating the camshaft and with a fuel pressurization chamber (21) for pressurizing fuel. The plunger reciprocates due to the rotation of the cam to pressurize and to pressure-feed the fuel suctioned into the fuel pressurization chamber. The camshaft is rotatably held by bearings (13) formed in the housing at sliding faces (11a) formed on the camshaft on both sides of the cam. The fuel supply pump is formed with a lubricating passage (11 b) for introducing the fuel in the cam chamber into a space be-

tween at least one of the sliding faces and the bearing.

Claims

1. A high-pressure fuel supply pump (4) comprising:

a camshaft (11);
a cam (14) that is provided on the camshaft such that a central axis of the cam is deviated from a central axis of the camshaft and that rotates with the camshaft;
a housing (12, 20) formed with a cam chamber (27) for accommodating the camshaft and with a fuel pressurization chamber (21) for pressurizing the fuel; and
a plunger (19) that reciprocates due to the rotation of the cam to pressurize and to pressure-feed the fuel suctioned into the fuel pressurization chamber, wherein
the camshaft is rotatably held by a bearing provided in the housing at sliding faces (11a) defined by outer peripheral surfaces of the camshaft on both sides of the cam, and
the high-pressure fuel supply pump is formed with a first lubricating passage (11 b) for introducing the fuel in the cam chamber into a space between at least one of the sliding faces and the bearing.

2. The high-pressure fuel supply pump as in claim 1, wherein
the first lubricating passage is formed on at least one of the sliding faces of the camshaft.

3. The high-pressure fuel supply pump as in claim 1 or 2, wherein
the first lubricating passage extends in a direction inclined with respect to a rotation central axis of the camshaft.

4. The high-pressure fuel supply pump as in any one of claims 1 to 3, wherein
the first lubricating passage is provided by forming a concave portion on the sliding face of the camshaft.

5. The high-pressure fuel supply pump as in claim 1 or 2, wherein
the first lubricating passage is provided by forming a chamfer on the sliding face of the camshaft.

6. The high-pressure fuel supply pump as in any one of claims 1 to 3, wherein
the first lubricating passage is provided by forming a groove on the sliding face of the camshaft.

7. The high-pressure fuel supply pump as in any one of claims 1 to 6, wherein

the first lubricating passage opens into one of manufacturing clearance grooves formed on the camshaft on the both sides of the cam.

8. The high-pressure fuel supply pump as in claim 1, wherein
the first lubricating passage is formed on an inner peripheral surface of the bearing.

9. The high-pressure fuel supply pump as in any one of claims 1 to 8, wherein
the first lubricating passage is formed in an area, to which a reaction force of the fuel pressure-feeding operation of the plunger is not applied.

10. The high-pressure fuel supply pump as in any one of claims 1 to 9, wherein
the cam is formed with a second lubricating passage (14b) on a cam sliding face (14a) defined by an outer peripheral surface of the cam for introducing the fuel in the cam chamber into a space between the cam sliding face (14a) and an intermediate member (16), through which the cam applies a force to the plunger.

11. The high-pressure fuel supply pump as in claim 10, wherein
the second lubricating passage extends in a direction inclined with respect to a rotation central axis of the cam.

12. The high-pressure fuel supply pump as in claim 10 or 11, wherein
the second lubricating passage is provided by forming a concave portion on the cam sliding face of the cam.

13. The high-pressure fuel supply pump as in claim 10, wherein
the second lubricating passage is provided by forming a chamfer on the cam sliding face of the cam.

14. The high-pressure fuel supply pump as in claim 10 or 11, wherein
the second lubricating passage is provided by forming a groove on the cam sliding face of the cam.

15. The high-pressure fuel supply pump as in any one of claims 10 to 14, wherein
the second lubricating passage opens into the manufacturing clearance grooves.

16. The high-pressure fuel supply pump as in any one of claims 10 to 15, wherein
the second lubricating passage is formed in an area, to which a reaction force of the fuel pressure-feeding operation of the plunger is not applied.

17. The high-pressure fuel supply pump as in any one

of claims 1 to 16, wherein
the high-pressure fuel supply pump is used to supply
high-pressure fuel to a common rail (3) of a common
rail fuel injection device of a diesel engine (1).

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FIG. 1

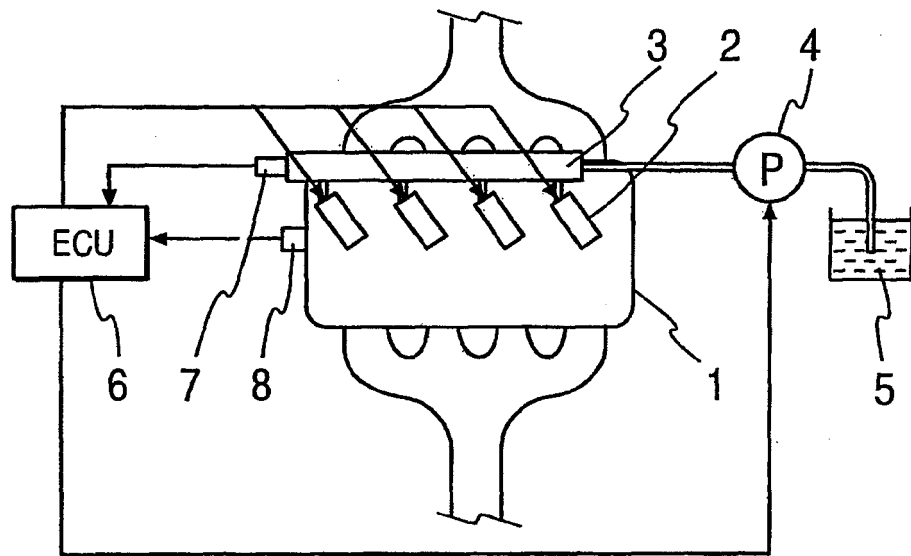


FIG. 4

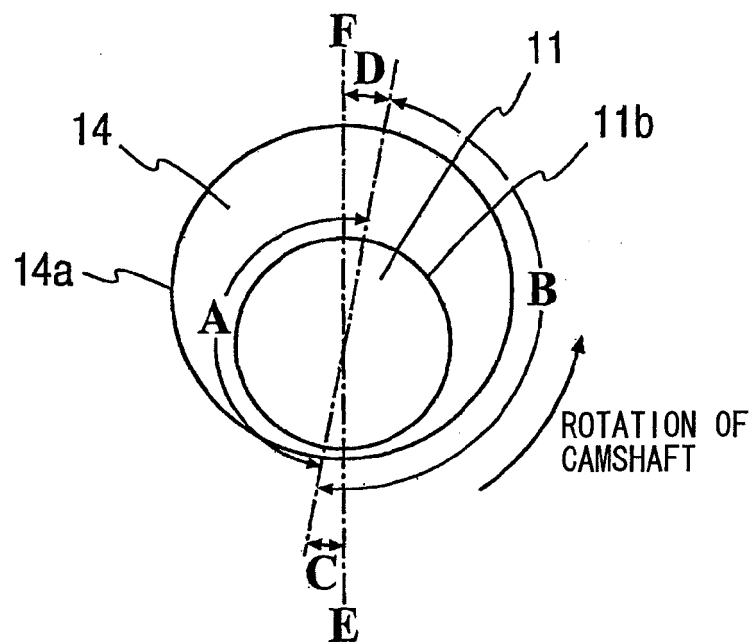


FIG. 2

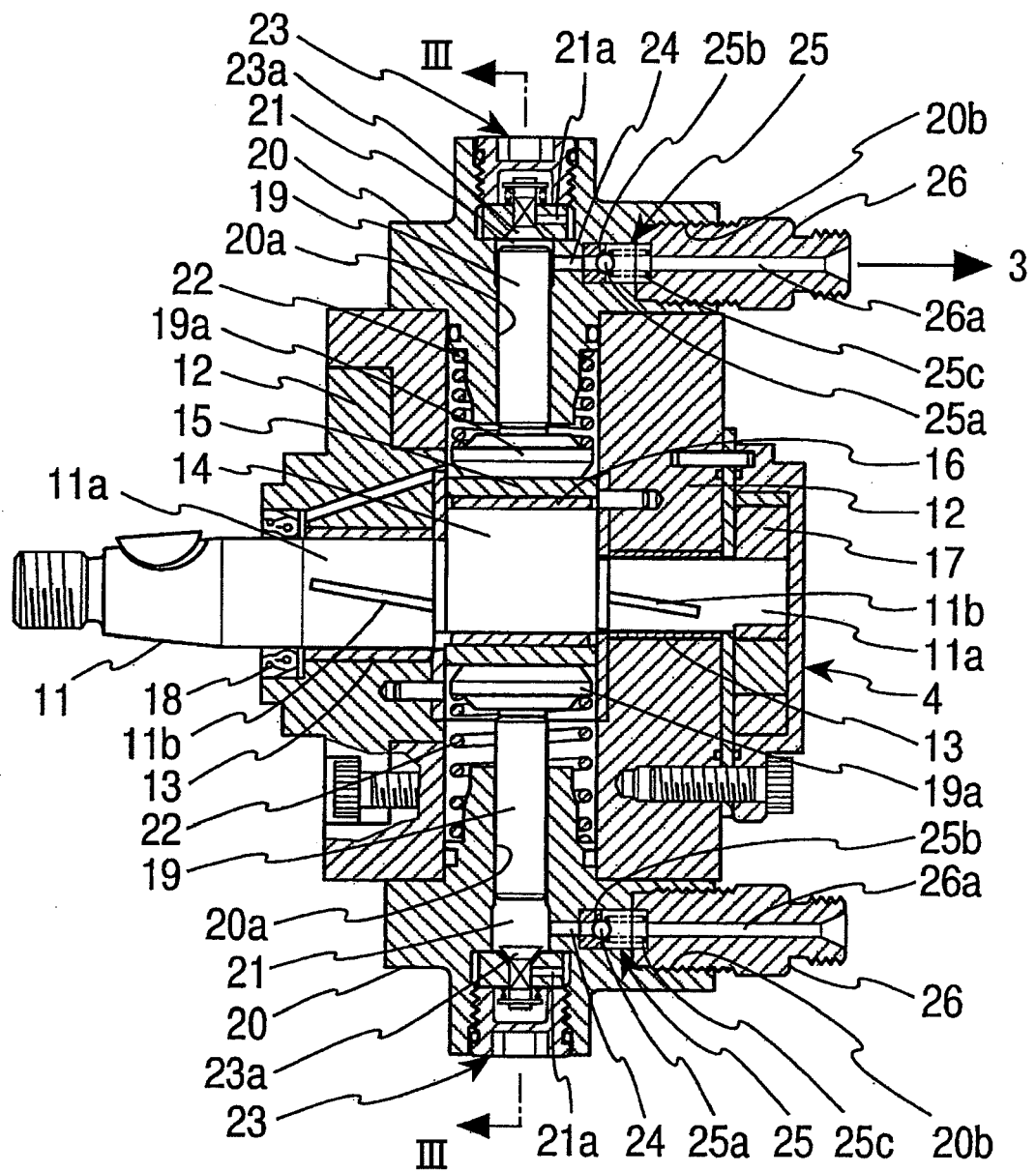


FIG. 3

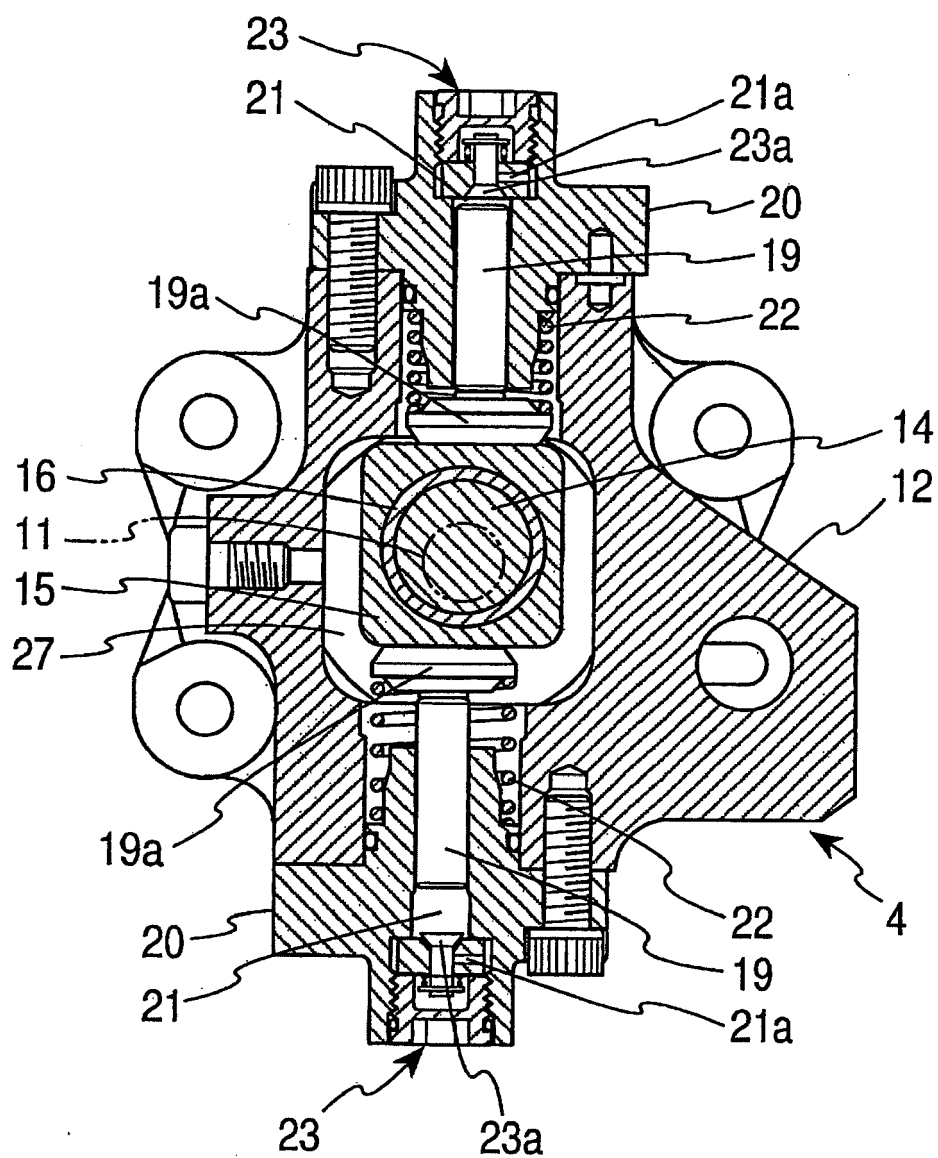


FIG. 5

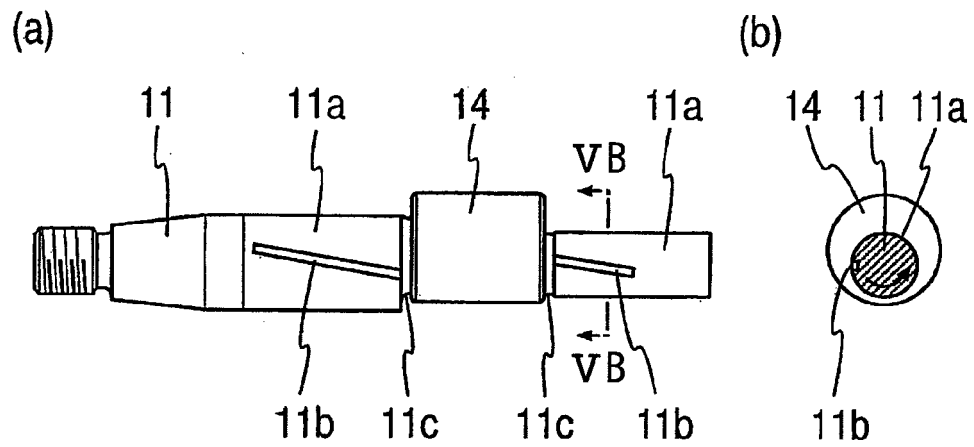


FIG. 6

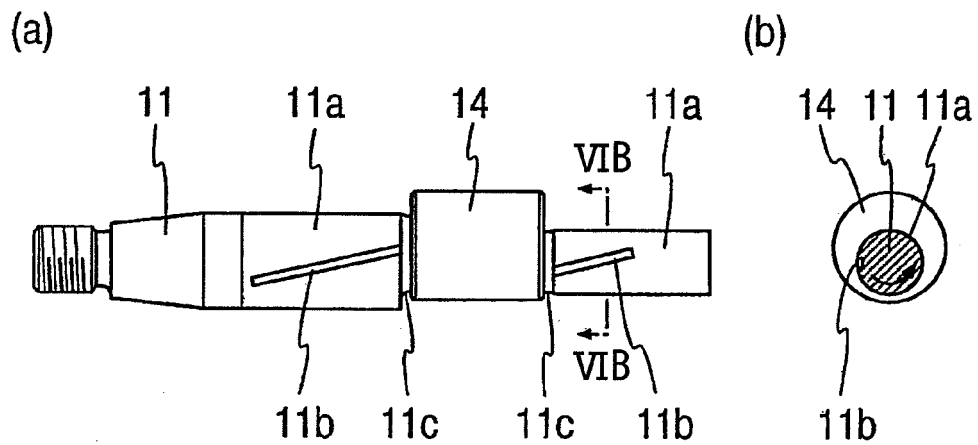


FIG. 7

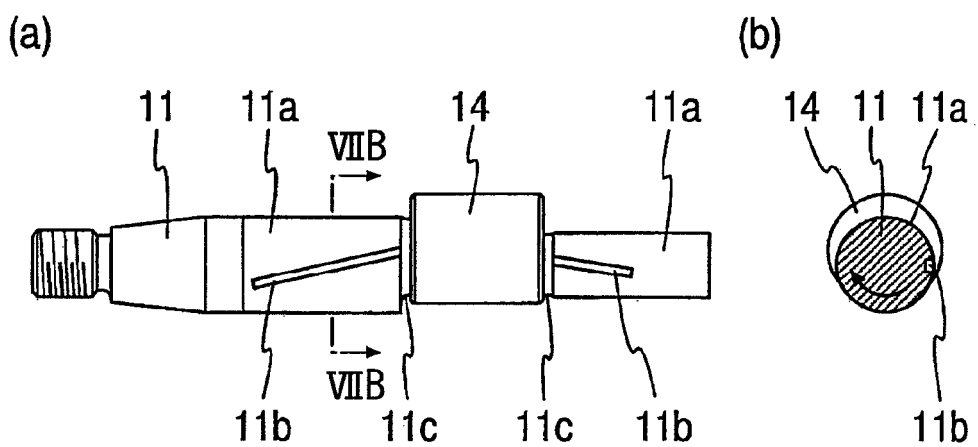


FIG. 8

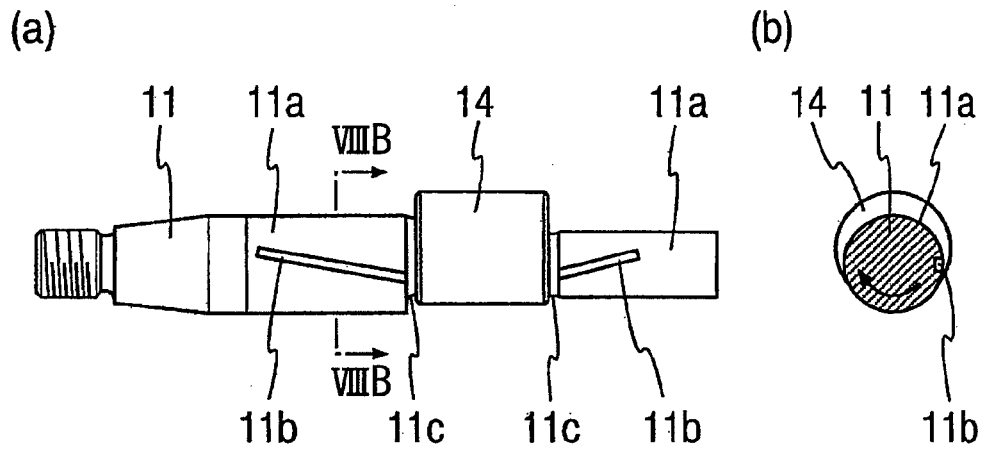


FIG. 9

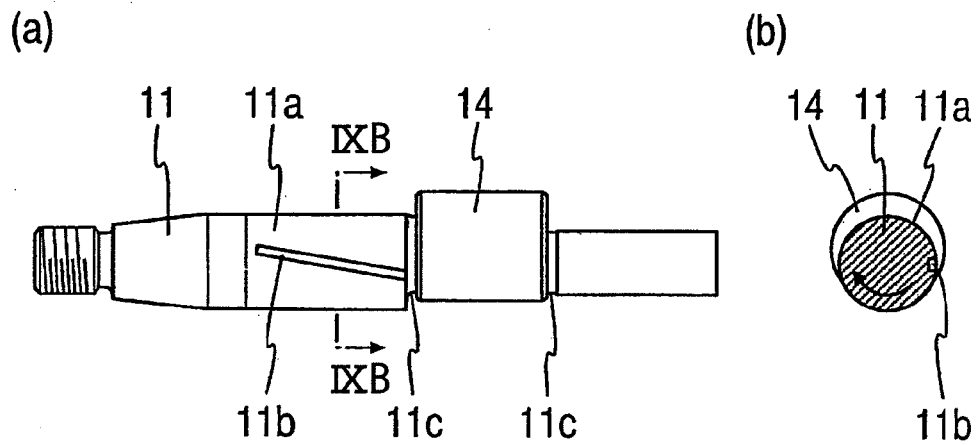


FIG. 10

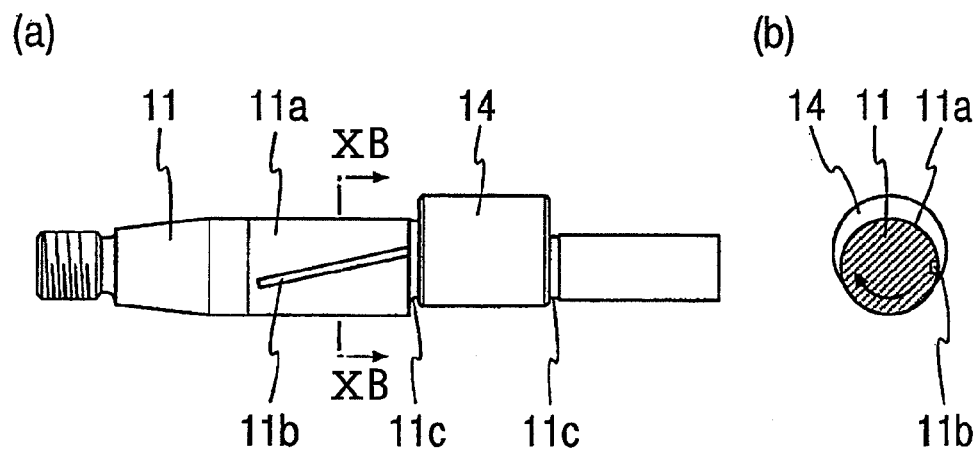


FIG. 11

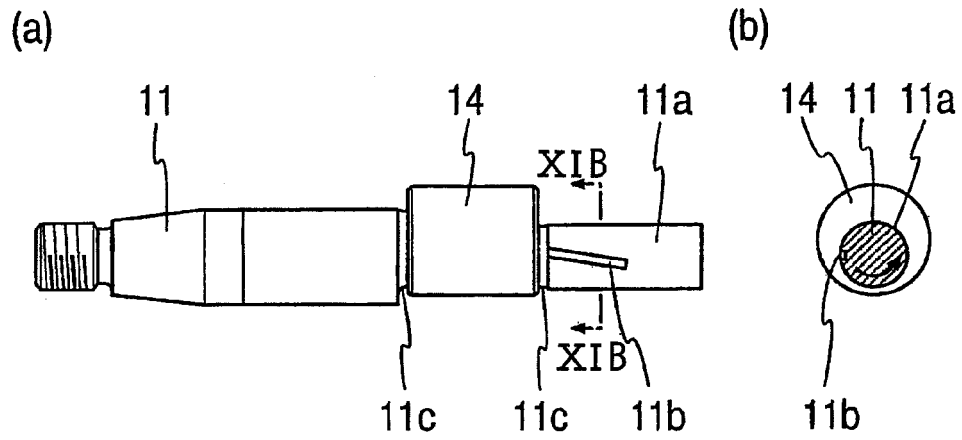


FIG. 12

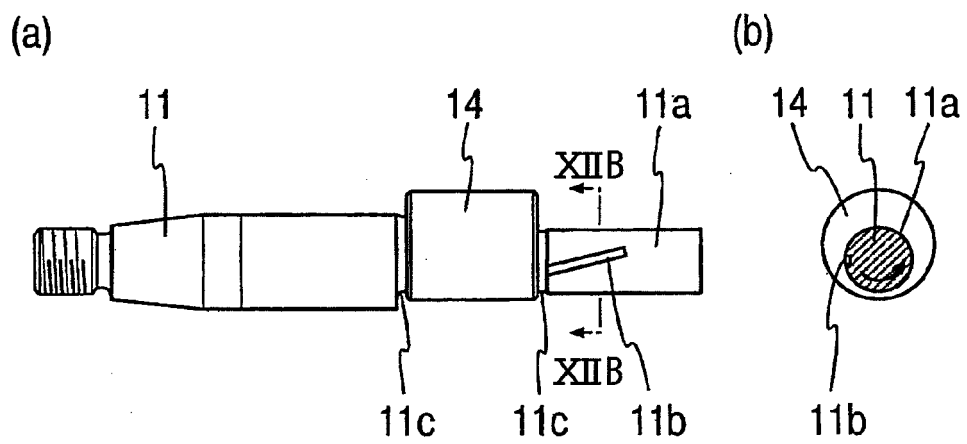


FIG. 13

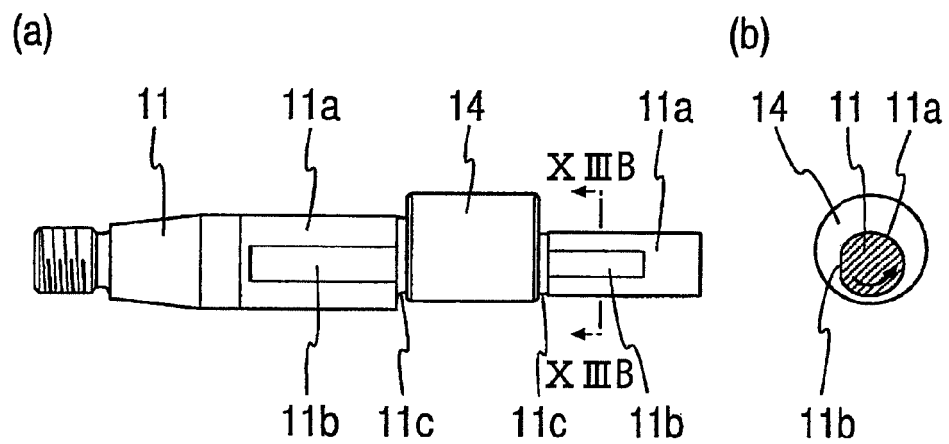


FIG. 14

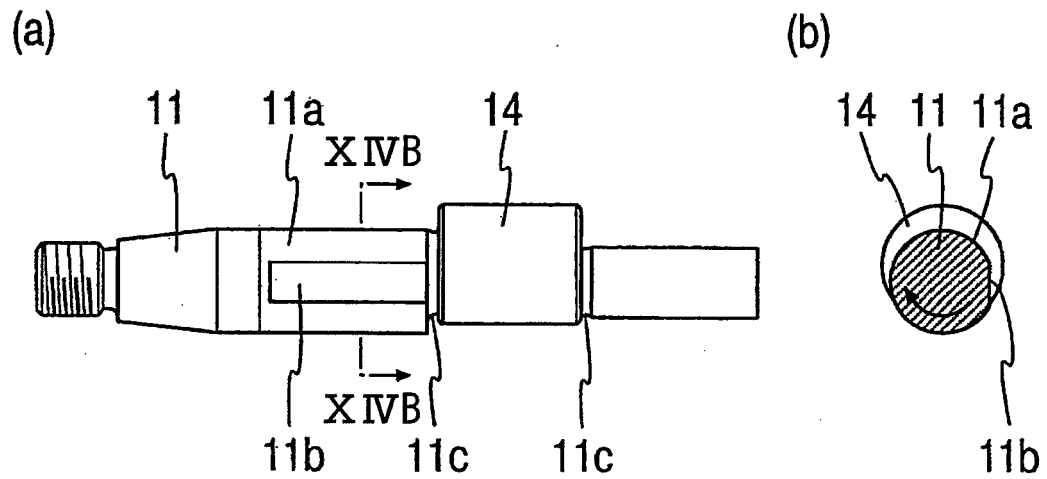


FIG. 15

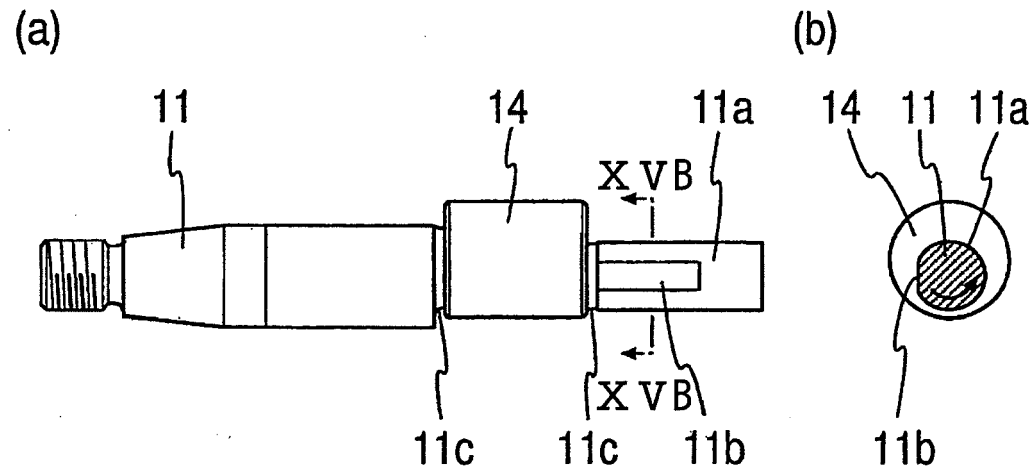


FIG. 16

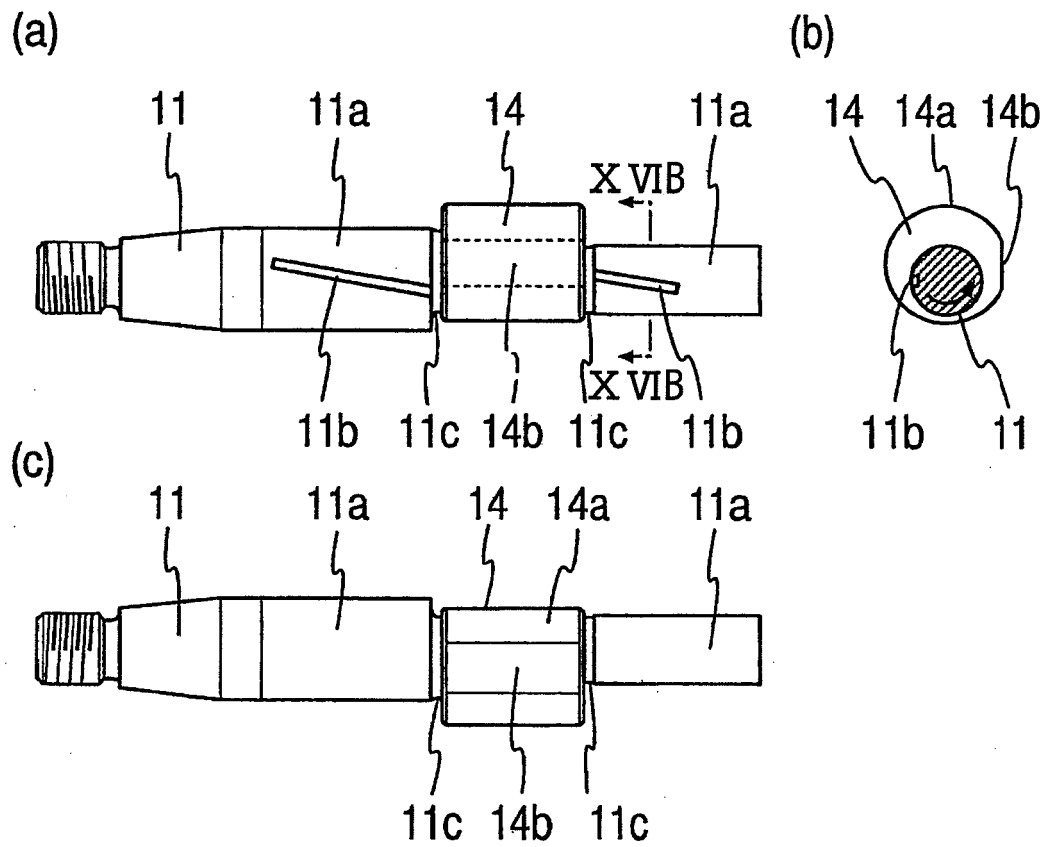


FIG. 17

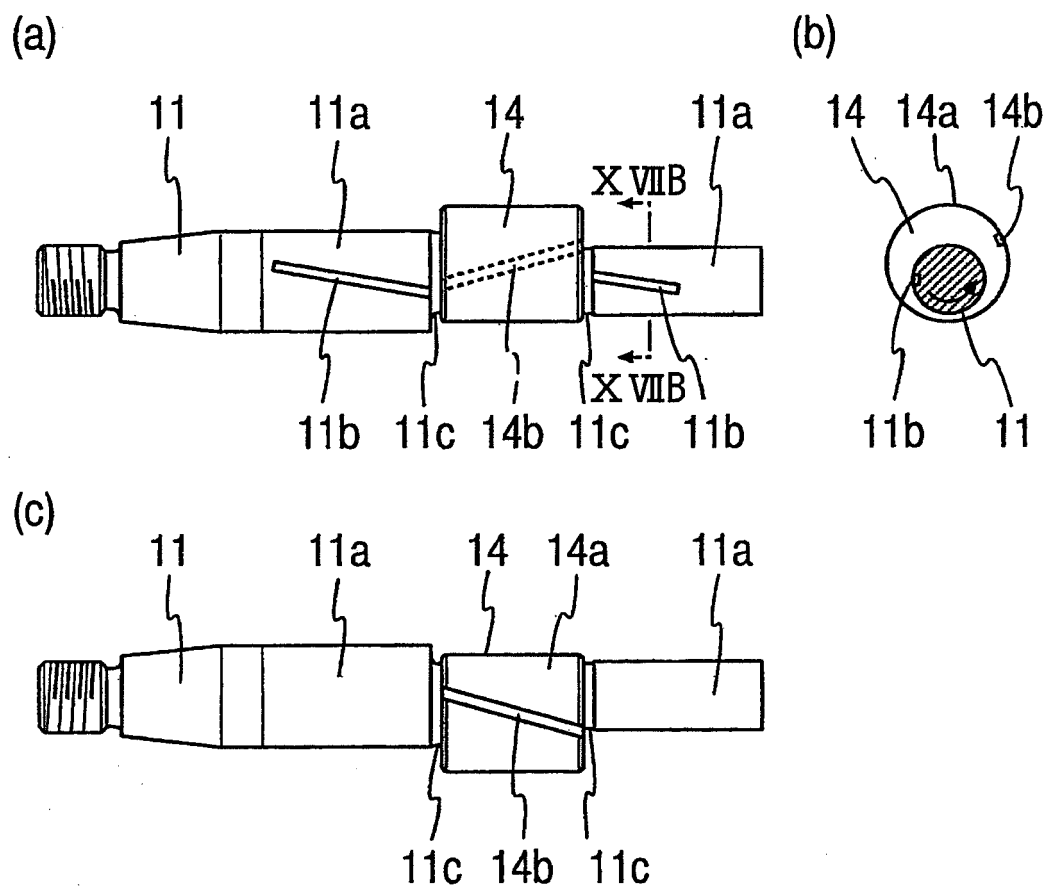


FIG. 18

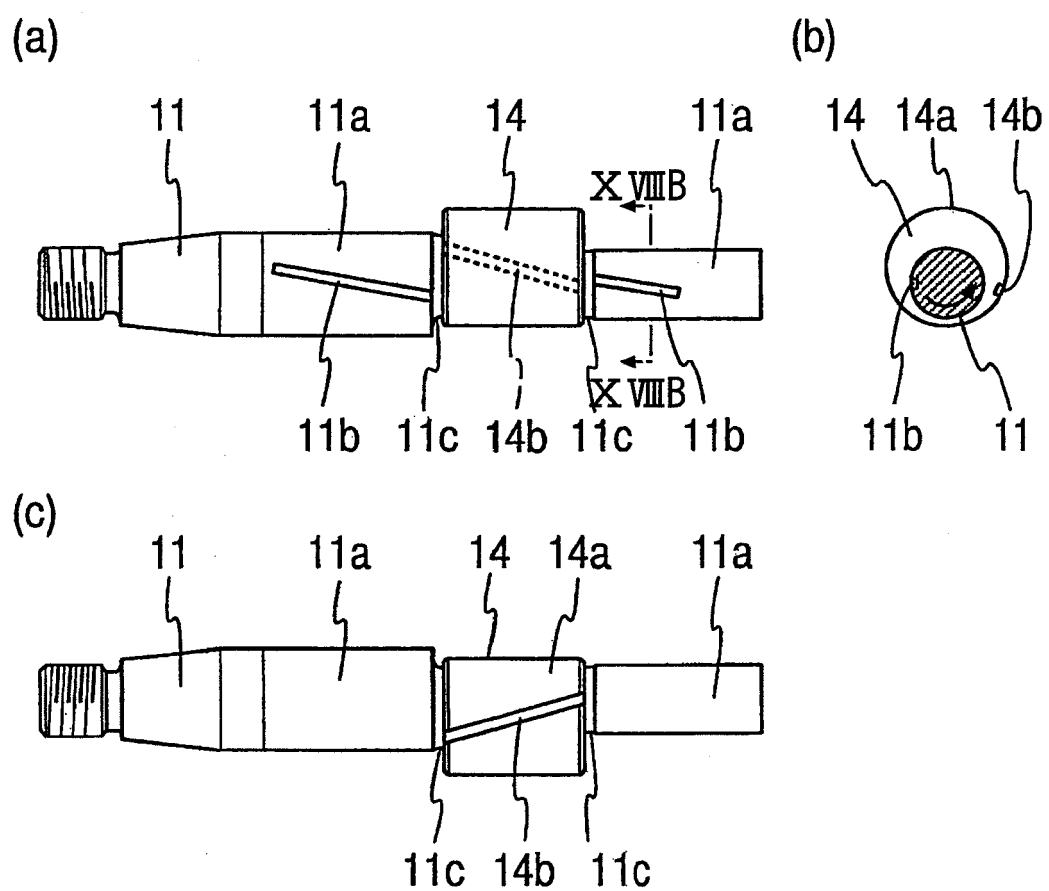


FIG. 19

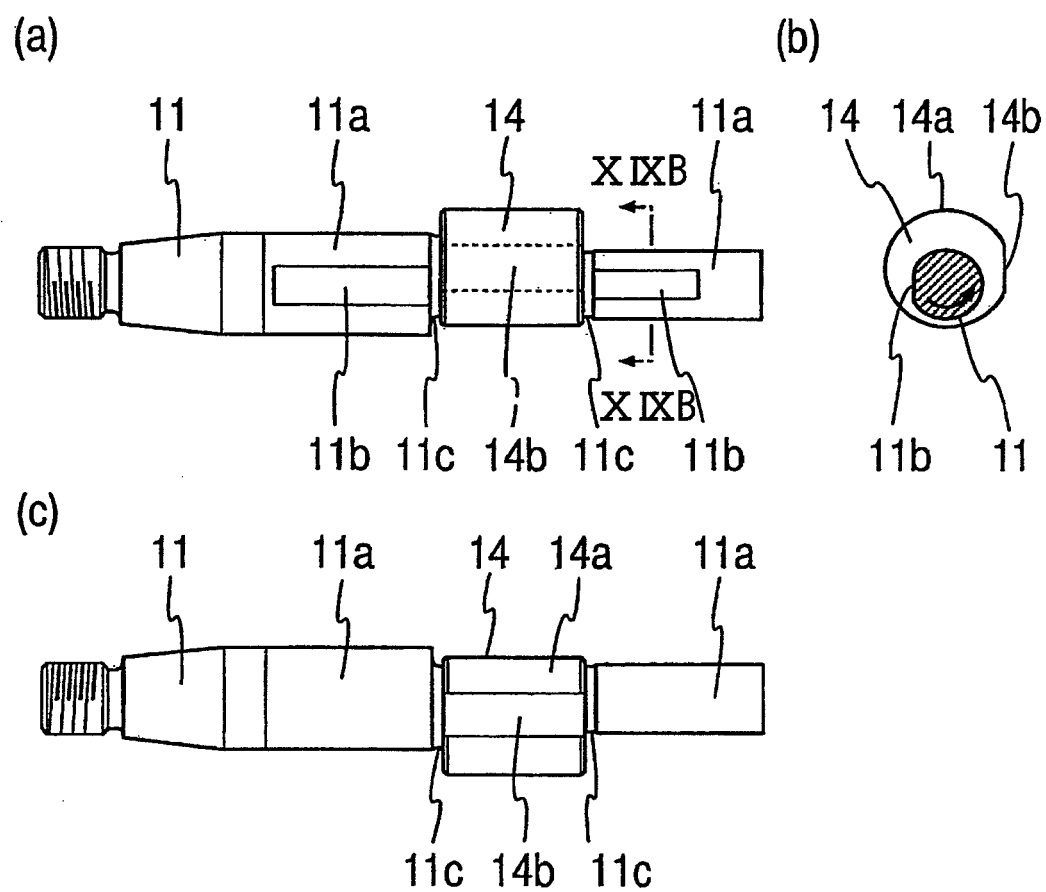


FIG. 20

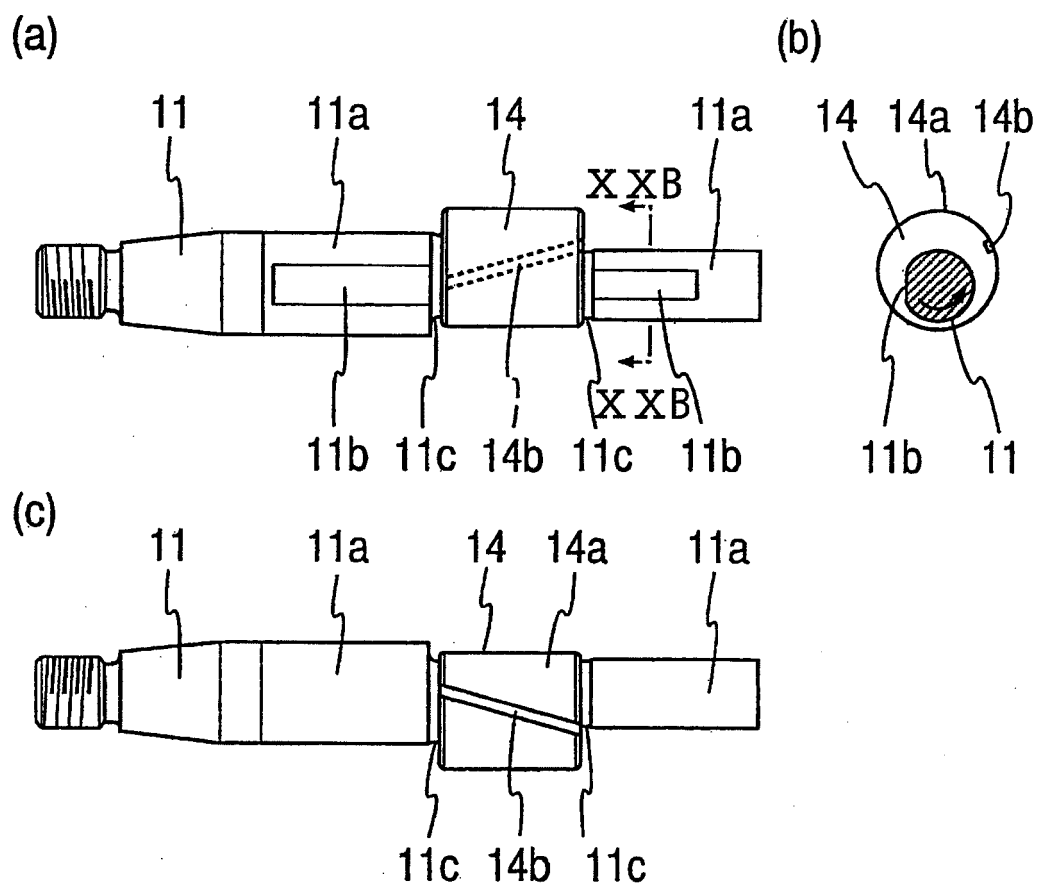
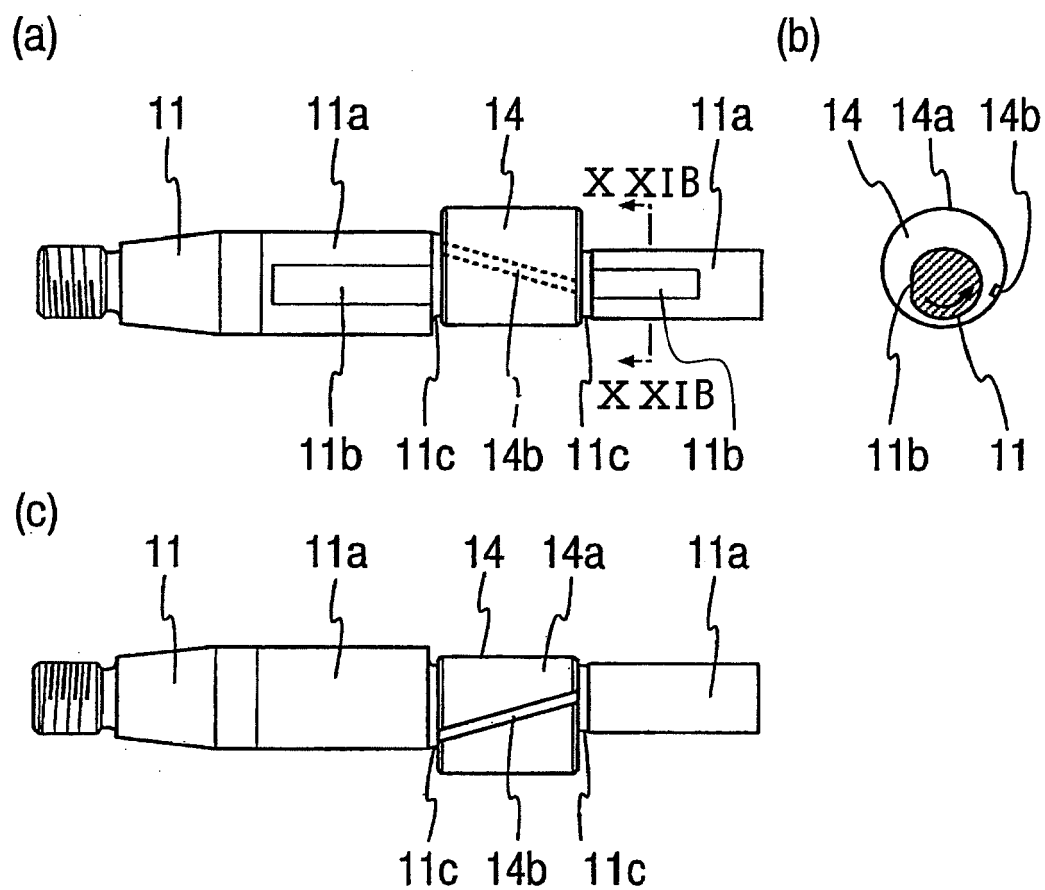


FIG. 21





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X	DE 102 08 574 A1 (BOSCH GMBH ROBERT [DE]) 12 June 2003 (2003-06-12) * paragraphs [0024] - [0027], [0032]; figure 3 *	1-17	INV. F02M59/06 F02M59/10 F04B1/04 F04B53/18
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			F02M F04B
Place of search		Date of completion of the search	Examiner
Munich		22 November 2006	LANDRISCINA, V
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22-11-2006

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