

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 665 373 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:

10.05.2000 Bulletin 2000/19

(51) Int. Cl.⁷: **F02M 59/26**

(21) Application number: **94120704.5**

(22) Date of filing: **27.12.1994**

(54) Fuel injection pump

Kraftstoffeinspritzpumpe

Pompe d'injection de combustible

(84) Designated Contracting States:
DE GB

(30) Priority: **28.12.1993 JP 34917093**
28.12.1993 JP 34917693
28.12.1993 JP 34918193

(43) Date of publication of application:
02.08.1995 Bulletin 1995/31

(73) Proprietor: **ZEXEL CORPORATION**
Tokyo (JP)

(72) Inventors:

- **Kato, Hiroaki,**
c/o Zexel Corporation
Higashi-Matsuyama City, Saitama Pref. (JP)
- **Yashiro, Hidekatsu,**
c/o Zexel Corporation
Higashi-Matsuyama City, Saitama Pref. (JP)

- **Kodama, Tsuyoshi,**
c/o Zexel Corporation
Higashi-Matsuyama City, Saitama Pref. (JP)

(74) Representative:
Grünecker, Kinkeldey,
Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(56) References cited:
EP-A- 0 294 822

- **PATENT ABSTRACTS OF JAPAN vol. 4, no. 150**
(M-037) 22 October 1980 & JP-A-55 101 761
(MITSUBISHI) 4 August 1980
- **PATENT ABSTRACTS OF JAPAN vol. 9, no. 67**
(M-366) (1790) 27 March 1985 & JP-A-59 200 060
(HINO) 13 November 1993

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 665 373 B1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] This invention relates to a fuel injection pump, according to the preamble of claim 1 and more particularly to a fuel injection pump provided in its plunger barrel with a feed hole constituted as a main port and a sub-port and to a fuel injection pump for delivering pressurized fuel to a throttling-type fuel injection nozzle in an auxiliary combustion chamber of a divided-chamber combustion system diesel engine. Furthermore the invention relates to a combination of a fuel injection pump and an injection nozzle.

Prior Art

[0002] A generally preferred feature of a fuel injection pump is that it be capable of advancing the start of fuel injection (fuel injection advance) during high-speed engine operation. Some of the fuel injection pumps with this feature have a fuel injection timing regulation mechanism that is part of the fuel injection pump itself and therefore do not require a separate timer (automatic advance device) for regulating the injection timing.

[0003] Some of these timing regulation mechanisms utilize the preflow effect arising at high engine speed to establish a fuel injection advance characteristic. (The preflow effect is a dynamic effect (throttle effect) which causes pressurized fuel to be delivered prior to the closure of the fuel feed hole.)

[0004] Although the preflow effect can be used for achieving good fuel injection timing during high-speed engine operation, it has a drawback in not being easy to apply for realizing overall optimum timing because it retards the start of fuel injection (fuel injection retard) during engine starting and at the torque points (low speed, high load).

[0005] A need therefore exists for a fuel injection pump capable of advancing the fuel injection point both during high-speed engine operation and during engine starting as well as of establishing the desired fuel injection advance characteristic with respect to the load state (low load, high load) of the engine.

[0006] In response to this need, there has been proposed a fuel injection pump in which the feed hole is constituted as a main port and a sub-port, an upper main lead groove is formed to communicate with the main port and an upper sub-lead groove is formed to communicate with the sub-port. With this configuration, the preflow effect can be obtained during high-speed engine operation, the fuel injection point can be advanced during engine starting, and the desired fuel injection advance characteristic can be established with respect to the load state (low load, high load) and speed (low speed, high speed) of the engine.

[0007] While the fuel injection pump employing the preflow effect in this manner enables the fuel injection advance to be set as desired according to the load state and the engine speed, it is, however, capable of utilizing the preflow effect only for controlling the time point at which fuel injection starts.

[0008] With this type of fuel injection pump, moreover, the cam lift is increased by the amount of the preflow stroke and, as a result, the fuel is delivered at the portion of the cam where the fuel delivery rate is high. Since the resulting tendency for the fuel injection rate to be high makes it impossible to reduce the maximum fuel injection during low-speed and high-load operation, it is difficult to control the generation of black smoke and particulates.

[0009] There have also been developed fuel injection pumps which not only achieve improved injection characteristics by appropriately controlling the start of fuel injection in the foregoing manner but also achieve a further improvement in the injection characteristics by constituting the feed hole in the plunger barrel as a combination of a large-diameter main port and a small-diameter sub-port, thereby enabling appropriate control of the end of fuel injection and realizing improved fuel cutoff and better control of fuel injection quantity in response to load changes.

[0010] A fuel injection pump according to the preamble of claim 1 is known from JP-A-55-101761. It teaches a fuel injection pump provided with a set of large-diameter discharge ports 8b constituting a main port, a set of small-diameter discharge ports 8a constituting a sub-port, a first plunger lead groove 14b and a second plunger lead groove 14a, and further provided on the plunger head with a control land 15 for controlling the opening/closing of the large-diameter discharge ports. The control land produces a preflow effect and fuel is spilled from the small diameter discharge ports 8a on the low-load side, thereby preventing a sudden drop in the fuel injection quantity during low-speed, low-load operation.

[0011] This arrangement is disadvantageous, however, because it requires provision of both the main port and the sub-port as sets of discharge ports and also because the small-diameter discharge ports 8a are used for spilling fuel on the low-load side, while on the high-load side the inability to spill fuel from the sub-port is apt to cause insufficient power output.

[0012] Two different combustion systems are utilized in prior art diesel engine combustion chambers: the direct-injection single-chamber combustion system and the indirect-injection divided-chamber combustion system. The former system is used mainly in large vehicles and the latter system mainly in small, general-purpose vehicles. Since combustion proceeds gradually following fuel injection in a diesel engine using the divided-chamber combustion system, it is possible to keep combustion noise low and suppress the generation of nitrogen oxides. This type of engine will be

explained briefly in the following.

[0013] A partial view of a known divided-chamber combustion system diesel engine 1 is shown in Fig. 1. The engine 1 comprises a cylinder 2 having a main combustion chamber 3 and an auxiliary combustion chamber 4. Pressurized fuel from a fuel injection pump 5 is injected through a fuel injection nozzle 6 into the auxiliary combustion chamber 4 where it is partially combusted. The partially combusted gas in the auxiliary combustion chamber 4 blows into the main combustion chamber 3 where it is completely combusted. The energy released by the combustion is converted into reciprocating motion by a piston 7.

[0014] Fig. 2 shows a partial view of another divided-chamber combustion system diesel engine (designated by reference numeral 8) having a swirl chamber 9.

[0015] Fig. 3 is a vertical sectional view of an ordinary fuel injection pump 5. The fuel injection pump 5 has a pump housing 10, a cam 12 mounted on a cam shaft 11 connected with the divided-chamber combustion system diesel engine 1 or 8, a fuel injection quantity control rack 13, a plunger barrel 14, a plunger 15, a delivery valve 16 and a delivery valve holder 17.

[0016] The power produced by the piston 7 of the diesel engine is transmitted through the cam shaft 11 to the cam 12 and used to vertically reciprocate the plunger 15 via a tappet roller 18.

[0017] The control rack 13 is linked with an accelerator pedal through a governor (neither shown) such that its position in the direction perpendicular to the drawing sheet varies with the degree of accelerator pedal depression. The movement of the control rack 13 is transferred through a fuel injection quantity control sleeve 19 to rotate the plunger 15 about its own axis by a corresponding angle.

[0018] The plunger barrel 14 is fixed inside the pump housing 10 and the plunger 15 is accommodated inside the plunger barrel 14 to be free to reciprocate vertically and rotate about its own axis. A fuel reservoir 20 is formed between the plunger barrel 14 and the pump housing 10 and a fuel chamber 21 is formed between the plunger 15 and the delivery valve 16.

[0019] The plunger barrel 14 is formed with a fuel feed hole 22. When the plunger 15 reciprocates inside the plunger barrel 14, fuel in the fuel reservoir 20 is sucked in through the feed hole 22 and pressurized in the fuel chamber 21. The pressure of the fuel in the fuel chamber 21 opens the delivery valve 16 and the pressurized fuel is delivered to the fuel injection nozzle 6 through a fuel injection pipe 23.

[0020] The peripheral portion at the head of the plunger 15 is formed with a vertical passage 24 communicating with the fuel chamber 21 and a lead groove 25 communicating with the vertical passage 24.

[0021] In the fuel injection pump 5 of this configuration, fuel is sucked from the fuel reservoir 20 through the feed hole 22 and into the fuel chamber 21 when the

plunger 15 moves downward.

[0022] When the plunger 15 thereafter moves upward, pressurization of the fuel in the fuel chamber 21 begins from the point that the upper end 15A of the plunger 15 closes off the feed hole 22. Delivery of pressurized fuel stops when the lead groove 25 opens the feed hole 22.

[0023] The portion of the stroke of the plunger 15 between its bottom dead point and the point at which pressurized fuel delivery starts is the prestroke and the portion thereof between closure of the feed hole 22 and the opening thereof is the effective stroke.

[0024] Fig. 4 shows a vertical sectional view of an ordinary fuel injection nozzle 6, which is of the throttling type. The fuel injection nozzle 6 has a nozzle body 26, a chip packing 27, a holder body 28, a retaining nut 29, a needle valve 30, a pressure spindle 31, a pressure spring 32, an adjustment shim 33, and a bar filter 34.

[0025] The fuel injection nozzle 6 is further formed with a fuel passage 35 running the length of the chip packing 27 and the holder body 28 and connected with the fuel injection pipe 23, and with a fuel reservoir 36, a nozzle hole 37 and a leak-off connection 38.

[0026] Fig. 5 is an enlarged sectional view of the nozzle hole 37 portion at the tip of the nozzle body 26. The nozzle hole 37 has a throttle-like configuration and a pin member 30A is formed to project from the tip of the needle valve 30. The pin member 30A is positioned within a cylindrical wall portion 37A of the nozzle hole 37 and a tapered portion 30B of the needle valve 30 is seated on a seat portion 37B of the nozzle hole 37.

[0027] The pressurized fuel received by the fuel injection nozzle 6 from the fuel injection pump 5 via the fuel injection pipe 23 passes through the fuel passage 35 and collects in the fuel reservoir 36. When the pressure of this fuel comes to exceed the force of the pressure spring 32 (the valve opening force), the needle valve 30 lifts, the pin member 30A opens the nozzle hole 37 and fuel is sprayed in the form of mist into the auxiliary combustion chamber 4 or the swirl chamber 9.

[0028] Fig. 6 is a graph showing how the opening area of the nozzle hole 37 varies with nozzle lift. As can be seen from this graph, the opening area remains constant from the time that the needle valve 30 starts to rise until just before the pin member 30A pulls completely out of the cylindrical wall portion 37A of the nozzle hole 37. Then when the tapered portion 30B separates completely from the seat portion 37B of the nozzle hole 37, the opening area increases rapidly.

[0029] Thus during the second half of the fuel injection a small lift of the needle valve 30 produces a large change in the opening area. It is therefore relatively easy to control generation of black smoke and particulates by regulating this lift to control the fuel injection rate. In addition, since the opening area remains substantially constant during the first half of the fuel injection and, further, since combustion starts gradually in the divided-chamber combustion system diesel engine

1 or 8 owing to the small amount of air in the auxiliary combustion chamber 4 or swirl chamber 9 at the time of ignition, the arrangement is suitable for reducing combustion noise and the formation of nitrogen oxides.

[0030] Since the throttling type fuel injection nozzle 6 is therefore adapted for use in a divided-chamber combustion system diesel engine such as 1 or 8, its basic utilization is in small divided-chamber combustion system diesel engines.

[0031] Contrary to the foregoing, however, the divided-chamber combustion system diesel engine equipped with an auxiliary cylinder such as the auxiliary combustion chamber 4 or the swirl chamber 9 is, under certain circumstances, apt to promote generation of smoke and particulates. This is particularly likely to happen when the fuel injection rate is high during low-speed, high load operation because the small size of the auxiliary combustion chamber compared with the main combustion chamber 3 limits the amount of air that can contribute to combustion.

[0032] For improving fuel cutoff, controlling fuel injection quantity in response to load changes and otherwise improving injection characteristics, there has been developed a fuel injection pump in which the feed hole 22 is formed as a large-diameter main port and a small-diameter sub-port is formed separately in the plunger barrel 14.

[0033] JP-A-56-27062, for example, teaches a fuel injection device formed with a discharge port 62 constituting a main port, a small fuel cutoff port 63 constituting a sub-port, a main lead groove 51 and a fuel cutoff lead 52. On the high load side, fuel is spilled from the small fuel cutoff port 63 and the spill pressure is applied as back pressure to the needle valve 11 of a hole-type fuel injection nozzle.

[0034] Since this fuel injection is designed for use in combination with a hole-type fuel injection nozzle used in a direct-injection diesel engine, it is not suitable for use in a small divided-chamber combustion system engine.

[0035] On the other hand, the fuel injection pump taught by JP-A-56-54957 is formed with large-diameter discharge port 8b constituting a main port, a small-diameter discharge port 8a constituting a sub-port, a plunger lead groove 15b for the large-diameter discharge port, and a plunger lead groove 15a for the small-diameter discharge port, and is used in combination with a variable retraction delivery valve. On the low-load side, fuel is spilled from the small-diameter discharge port 8a, while during low-load operation, the fuel injection quantity is basically maintained but is reduced on the low-speed, low-load side.

[0036] This arrangement is not completely satisfactory because, first, it has to be used with a variable retraction delivery valve and, second, the engine output is apt to become insufficient on the low-load side owing to the spilling of fuel from the small-diameter discharge port 8a.

[0037] The fuel injection pump taught by JP-A-55-101761 is formed with a set of large-diameter discharge ports 8b constituting a main port, a set of small-diameter discharge ports 8a constituting a sub-port, a first plunger lead groove 14b and a second plunger lead groove 14a, and further provided on the plunger head with a control land 15 for controlling the opening/closing of the large-diameter discharge ports 8b. The fuel injection quantity is prevented from falling sharply during low-speed, low-load operation by spilling fuel from the small-diameter discharge ports 8a on the low-load side.

[0038] This arrangement is disadvantageous, however, because it requires provision of both the main port and the sub-port as sets of discharge ports and also because the use of the small-diameter discharge ports 8a for spilling fuel on the low-load side tends to cause insufficient power output.

[0039] JP-A-55-101761 deals with the problem of fuel injection in the low speed/low load region, i.e. engine idling, and intends to avoid a sharp drop in the amount of fuel injection under these engine running conditions.

[0040] According to the prior art reference, under low load conditions the small diameter holes are opened earlier than the large diameter holes, whereas under high load operation the large diameter holes are opened first. In both cases, the amount of fuel injected (not the fuel injection rate) is increased owing to the land under low load operation (per flow effect) and to an after flow effect under high load operation (because of the small diameter holes). However, the quality of the exhaust gas does not only depend on the total amount of fuel supplied per stroke of injection pump but also on the fuel supply rate during the stroke.

[0041] In contrast thereto, the present invention intends to reduce the amount of smoke and particles under high load operation and low speed. According to the present invention, this problem is tackled not by changing the amount of fuel supply by the injection pump per stroke but by measures concerning the amount of fuel supplied by per time unit, i.e. the fuel supply rate.

[0042] The applicant has found out that the amount of smoke and particles in the exhaust gas can be reduced by decreasing the maximum fuel injection rate during low speed and high load operation, which according to the present invention is achieved under high load operation by opening the sub feed port first.

[0043] The technical problem mentioned above is solved by a fuel injection pump according to claim 1 and, moreover, by the combination of a fuel injection pump and an injection nozzle according to claim 15.

[0044] According to the present invention and in contrast to the prior art pump, the main feed port therefore cooperates with a main lead groove having a sharp inclination while the sub feed port cooperates with a lower sublead groove, in addition to the main sub lead groove having a lower inclination. Thus, according to the

present invention, during low load operation, either the main feed port or the sub feed port comes into communication with the respective groove, whereas under high load operation the sub feed port comes into communication with the lower sub lead groove earlier than the main feed port. Thus, the maximum fuel injection rate during low speed and high load operation decreases owing to fuel spill from the sub feed port before the end of the injection which is accomplished when the main feed port finally communicates with the lower main lead groove.

[0045] When the fuel is injected uniformly in the cylinder of an engine, a more homogenous mixture in the cylinder can be obtained which results in a reduction of smoke and particles which are normally caused by a lack of air

[0046] Furthermore it is possible, at the rotational position of the plunger during high-load operation, to prevent the main port from communicating with the lower main lead groove even then the sub-port comes into communication with the lower sub-lead groove owing to movement of the plunger in the fuel delivery direction and, further, at the rotational position of the plunger during low-load operation, to prevent the sub-port from communicating with the lower sub-lead groove even when the main port comes into communication with the lower main lead groove owing to movement of the plunger in the fuel delivery direction.

[0047] As a specific configuration for ensuring that at the rotational position of the plunger during high-load operation the main port does not communicate with the lower main lead groove even when the sub-port communicates with the lower sub-lead groove and ensuring that at the rotational position of the plunger during low-load operation the sub-port does not communicate with the lower sub-lead groove even when the main port communicates with the lower main lead groove, it is possible, for example, to provide the lower main lead groove and the lower sub-lead groove with slopes in the direction from the low-load side to the high-load side and in the downward direction of the plunger such that the slope of the lower main lead groove is greater than that of the lower sub-lead groove.

[0048] Alternatively, it is possible to form the sub-port in the plunger barrel at a lower position than that at which the main port is formed therein and to appropriately select the slopes of the lower main lead groove and the lower sub-lead groove by, for example, sequentially varying them in accordance with the load.

[0049] An arrangement enabling a preflow effect may involve the drawbacks discussed earlier. Specifically, since fuel is released from the sub-port during low-speed operation by an amount corresponding to the preflow stroke and fuel is delivered after the sub-port is closed, i.e. since fuel spill (delivery cutoff) is conducted by the sub-port and the sub-lead groove, the fuel injection rate becomes high during low-speed operation owing to the use of the high-speed portion of the cam.

However, this problem is overcome by the formation of the lower main lead groove and the lower sub-lead groove which, by enabling setting of the fuel injection cutoff time, make it possible to control fuel spill even during low-speed operation. In addition, by selecting the relationship between the slopes of the lower main lead groove and the lower sub-lead groove it is possible to select the load region within which the fuel injection cutoff time can be set and, in particular, to select the load region within which the fuel injection cutoff time is not set.

[0050] Still further, by selecting the relationship between the slopes of the lower main lead groove and the lower sub-lead groove it is possible to select the load region within which fuel is spilled from the sub-port portion and the sub-port spill stroke (the stroke of the plunger after spill from the sub-port up to the start of spill from the main port).

[0051] Moreover, since the upper sub-lead groove and the upper main lead groove are formed and the main port and the sub-port can be closed by portions of the upper end of the plunger where they are not formed, the amount of fuel injection advance during starting can be set as desired.

[0052] Since, particularly at the rotational position of the plunger during high-load operation of the diesel engine, the time at which the sub-port communicates with the lower sub-lead groove is earlier than the time at which the main port communicates with the lower main lead groove, i.e. since during high-load operation fuel spills from the sub-port before spilling from the main port, the dynamic effect (throttling effect) of the sub-port during high-speed operation reduces the amount of fuel spill from the sub-port to a low level, making it possible to secure a normal delivery amount. On the other hand, since fuel spills from the sub-port during low-speed operation thereby enabling reduction of the maximum fuel injection rate during low-speed, high-load operation, it is possible to reduce generation of black smoke and particulates particularly in the case of a divided-chamber combustion system diesel engine using a throttling type fuel injection nozzle.

BRIEF DESCRIPTION OF THE DRAWINGS

[0053]

Fig. 1 is a schematic view of a part of a known divided-chamber combustion system diesel engine 1 which uses an auxiliary combustion chamber 4 as a subsidiary combustion chamber.

Fig. 2 is a schematic view of a part of a known divided-chamber combustion system diesel engine 8 which uses a swirl chamber 9 as a subsidiary combustion chamber.

Fig. 3 is a vertical sectional view of an ordinary fuel injection pump 5.

Fig. 4 is a vertical sectional view of an ordinary

throttling type fuel injection nozzle 6.

Fig. 5 is an enlarged sectional view of the nozzle hole 37 portion at the tip of the nozzle body 26 of the fuel injection nozzle 6 of Fig. 4.

Fig. 6 is a graph showing how the opening area of the nozzle hole 37 of the fuel injection nozzle 6 varies with nozzle lift. 5

Fig. 7 is a vertical sectional view of a fuel injection pump 40 according to a first embodiment.

Fig. 8 is a vertical sectional view of an essential portion of the fuel injection pump 40 of Fig. 7. 10

Fig. 9 is a development of lead grooves at the head portion of a plunger 15 of the fuel injection pump 40.

Fig. 10 is a timing map shown within an N-Q characteristic diagram of the fuel injection pump 40. 15

Fig. 11 is a graph showing how fuel injection quantity Q varies with engine speed N in the fuel injection pump 40.

Fig. 12 is a graph showing how fuel injection quantity Q varies with engine speed N in the fuel injection pump 40 when a control rack 13 of the fuel injection pump 40 is immobilized. 20

Fig. 13 is a simplified development, similar to that of Fig. 9, for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 50 according to a second embodiment. 25

Fig. 14 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 51 which does not form a part of the invention. 30

Fig. 15 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 52 which is a third embodiment. 35

Fig. 16 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 56 which is a fourth embodiment.

Fig. 17 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 58 which is a fifth embodiment. 40

Fig. 18 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 59 which does not form part of the invention. 45

Fig. 19 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 60 which is a sixth embodiment. 50

Fig. 20 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 62 which is a seventh embodiment. 55

Fig. 21 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 63 which does not form part

of the invention.

Fig. 22 is a vertical sectional view of a fuel injection pump 70 which is an eighth embodiment.

Fig. 23 is a vertical sectional view of an essential portion of the fuel injection pump 70 of Fig. 22.

Fig. 24 is a development of lead grooves at the head portion of a plunger 15 of the fuel injection pump 70.

Fig. 25 is a timing map shown within an N-Q characteristic diagram of the fuel injection pump 70.

Fig. 26 is a simplified development, similar to that of Fig. 24, for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 71 which is a ninth embodiment.

Fig. 27 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 72 which is a tenth embodiment.

Fig. 28 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 74 which is a eleventh embodiment.

Fig. 29 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 75 which does not form part of the invention.

Fig. 30 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 76 which is a twelfth embodiment.

Fig. 31 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 78 which is a thirteenth embodiment.

Fig. 32 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 79 which does not form part of the invention.

Fig. 33 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 80 which is a fourteenth embodiment.

Fig. 34 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 82 which is a fifteenth embodiment.

Fig. 35 is an enlarged sectional view of an essential portion of the plunger barrel 14 and the plunger 15 of a fuel injection pump 90 which is a sixteenth embodiment.

Fig. 36 is a development of lead grooves at the head portion of a plunger 15 of the fuel injection pump 90.

Fig. 37 is a simplified explanatory view derived from Fig. 36.

Fig. 38 is a simplified development, similar to that of Fig. 37, for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 91

which is a seventeenth embodiment.

Fig. 39 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 92 which is an eighteenth embodiment.

Fig. 40 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 94 which is a nineteenth embodiment.

Fig. 41 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 96 which is a twentieth embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0054] The invention will be explained with reference to Figs. 7 to 21. A first embodiment of the fuel injection pump will be explained with reference to Figs. 7 to 12.

[0055] Fig. 7 is a vertical sectional view of the fuel injection pump 40 and Fig. 8 is a vertical sectional view of an essential portion thereof. Although the fuel injection pump 40 has basically the same structure as the fuel injection pump 5 described earlier with reference to Fig. 3, it differs therefrom in the configuration of the feed hole 22 portion formed in the plunger barrel 14 and the inclined lead groove 25 formed in the head portion of the plunger 15.

[0056] In the following explanation, therefore, portions of the fuel injection pump 40 which are similar to those of the fuel injection pump 5 are assigned the same reference symbols as those of fuel injection pump 5 and are not explained further.

[0057] Instead of being provided with a single feed hole, the plunger barrel 14 is formed with a large-diameter main port 41 and a small-diameter sub-port 42.

[0058] As shown in the enlarged view of Fig. 8, the upper edge 41A of the main port 41 and the upper edge 42A of the sub-port 42 are at the same height or horizontal level. They are formed over an interval of 180 degrees in the circumferential direction.

[0059] If necessary, the upper edge 41A of the main port 41 can instead be located at a lower level than the upper edge 42A of the sub-port 42.

[0060] When the plunger 15 reciprocates within the plunger barrel 14, fuel is drawn into the fuel chamber 21 from the fuel reservoir 22 and pressurized therein, whereupon the delivery valve 16 opens and pressurized fuel is delivered to the fuel injection nozzle through the fuel injection pipe 23 (Fig. 7).

[0061] When the fuel injection nozzle used is the throttling type fuel injection nozzle 6 (Fig. 4) suitable for use in a divided-chamber combustion system diesel engine such as the diesel engine 1 equipped with the auxiliary combustion chamber 4 (Fig. 1) or the diesel engine 8 equipped with the swirl chamber 9 (Fig. 2),

combustion proceeds gradually following partial fuel injection into the auxiliary combustion chamber 4 or 9, making it possible to keep combustion noise low and to suppress the generation of nitrogen oxides. In addition, since a small lift of the needle valve 30 produces a large change in the opening area, it is relatively easy to control generation of black smoke and particulates by regulating this lift to control the fuel injection rate.

[0062] Fig. 9 is a development of the lead grooves at the head portion of a plunger 15, showing the positional relationship between the main port 41 and the sub-port 42 at engine starting (broken lines) and at low-load operation and high-load operation (solid lines).

[0063] As shown by Figs. 8 and 9, the peripheral surface of the plunger head is formed with a vertical main passage 43 communicating with the fuel chamber 21, an inclined lower main lead groove 44 communicating with the vertical main passage 43, a vertical sub-passage 45 communicating with the fuel chamber 21, an upper sub-lead groove 47 communicating with the fuel chamber 21, and an inclined lower sub-lead groove 48 communicating with the vertical sub-passage 45.

[0064] Since the lower main lead groove 44 and the lower sub-lead groove 48 are both formed at positions below the upper end 15A of the plunger 15, they control the time at which spilling of the pressurized fuel (delivery cutoff) occurs.

[0065] The lower main lead groove 44 is formed to have a sharper slope than that of the lower sub-lead groove 48. Specifically, the lower main lead groove 44 and the lower sub-lead groove 48 are formed to slope in the direction from the low-load side to the high-load side and in the downward direction of the plunger 15 such that the slope of the lower main lead groove 44 is greater than that of the lower sub-lead groove 48.

[0066] As will be explained later with reference to other embodiments, however, the slopes of the lower main lead groove 44 and the lower sub-lead groove 48 can be suitably determined for appropriately selecting the fuel injection characteristics.

[0067] The region within which the sub-port 42 is opposite the upper sub-lead groove 47 corresponds to an engine load range extending from low load to high load. The region of the upper sub-lead groove 47 outside this region and the region of the upper end 15A of the plunger 15 outside that within which it is opposite the main port 41 correspond to the engine starting region.

[0068] Since the plunger 15 is reciprocated within the plunger barrel 14 by the cam 12, the upper sub-lead groove 47, the lower sub-lead groove 48, the vertical main passage 43 and the lower main lead groove 44 move vertically together relative to the stationary main port 41 and sub-port 42. This is shown in Fig. 9.

[0069] As also shown in Fig. 9, since the plunger 15 is rotated relative to the plunger barrel 14 by the action of the control rack 13, the upper sub-lead groove 47, the lower sub-lead groove 48, the vertical main passage 43

and the lower main lead groove 44 move laterally together relative to the stationary main port 41 and sub-port 42.

[0070] In the so-configured fuel injection pump 40, fuel is drawn into the fuel chamber 21 from the fuel reservoir 20 through the main port 41 and the sub-port 42 as the plunger 15 moves down.

[0071] As the plunger 15 rises, fuel pressurization starts from the point that the upper end 15A of the plunger 15 and the upper edge 47A of the upper sub-lead groove 47 close the main port 41 and the sub-port 42 and the delivery of pressurized fuel ends when the main port 41 is opened by the lower main lead groove 44 or when the sub-port 42 is opened by the lower sub-lead groove 48.

[0072] The part of the stroke of the plunger 15 from its bottom dead point to the start of fuel delivery is the prestroke and the part thereof from the closure of the sub-port 42 to the opening of the main port 41 is the effective stroke. The depth (height) of the upper sub-lead groove 47 is the prestroke L1.

[0073] The prestroke L1 is also the engine starting fuel injection advance with respect to low-speed operation.

[0074] More specifically, during engine starting neither the main port 41 nor the sub-port 42 is situated opposite the upper sub-lead groove 47; both face the upper end 15A in the engine starting region of the plunger 15.

[0075] Since the effective stroke for fuel delivery is therefore maximum, the fuel injection quantity required for starting the engine can be secured.

[0076] Since the upper sub-lead groove 47 is formed such that the upper end 15A of the plunger 15 is located above the upper edge 47A of the upper sub-lead groove 47, fuel injection is more advanced during engine starting than during low-speed/low-load operation.

[0077] During low-load and high-load engine operation, the main port 41 can be brought opposite the upper end 15A of the plunger 15 and the sub-port 42 can be brought opposite the upper sub-lead groove 47.

[0078] During idling or other such low-speed, low-load operation, the main port 41 is positioned to the left of the lower main lead groove 44 as seen in Fig. 9. The effective stroke is therefore short and, moreover, since the sub-port 42 is in communication with the upper sub-lead groove 47, substantial delivery of pressurized fuel starts from the closure of the sub-port 42 by the upper edge 47A of the upper sub-lead groove 47.

[0079] As the engine speed increases and a high-speed, low-load operating condition arises, the main port 41 remains to the left of the lower main lead groove 44 but the throttling effect of the sub-port 42 causes fuel delivery to start before the sub-port 42 is completely closed by the upper edge 47A of the upper sub-lead groove 47. As a result, fuel injection is advanced and the actual delivery stroke increased.

[0080] Fig. 10 is a timing map shown within an N-Q characteristic diagram. (In the following, the term "advance" will be used to mean "advance of the fuel injection point" and "retard" will be used to mean "retardation of the fuel injection point.")

[0081] As shown in this figure, an advance characteristic can be obtained during both engine starting and high-speed operation.

[0082] As shown best in Fig. 9, the point at which fuel delivery starts is the same during both low-load operation and high-load operation. Regarding the point at which fuel delivery ends, however, on the low-load side fuel first spills from the main port 41 while on the high-load side fuel first spills from the sub-port 42.

[0083] On the high-load side, the part of the stroke of the plunger 15 after spill from the sub-port 42 up to the start of spill from the main port 41 is the sub-port spill stroke.

[0084] On the low-load side, at the time that the main port 41 begins to spill fuel owing to the movement (rise) of the plunger 15 in the direction of fuel delivery, the sub-port 42 has still not come into communication with the lower sub-lead groove 48. It is therefore possible to achieve approximately the same injection characteristic as in the prior art fuel injection pump.

[0085] On the high-load side, since the main port 41 has not yet come into communication with the lower main lead groove 44 at the time fuel begins to spill from the sub-port 42, fuel is spilled from the sub-port 42, particularly during low-speed operation.

[0086] During high-speed operation, it is possible to achieve approximately the same injection characteristic as in the prior art since the sub-port 42 is kept substantially closed by its throttling effect even after it comes into communication with the lower sub-lead groove 48.

[0087] Fig. 11 is a graph showing how the fuel injection quantity Q varies with engine speed N. When the prior art fuel injection pump 5 (Fig. 3) is used in combination with an ordinary prior art throttling type fuel injection nozzle 6 (Fig. 4), the relationship between the cam speed and the fuel injection rate ΔQ at the torque point during low-speed, high-load operation exhibits a steep point (the protruding maximum fuel injection rate of the solid line curve), whereas, as can be seen from the broken-line curve, the fuel injection pump 40 according to the first embodiment of the invention exhibits a flatter curve and greatly reduces the maximum fuel injection rate.

[0088] In other words, during low-speed, high-load operation, fuel is slowly spilled from midway through the effective stroke in the course of the rise of the plunger 15 owing to the opening of the sub-port 42 by the lower sub-lead groove 48, and the resulting lowering of the fuel delivery rate during low-speed operation makes it possible to reduce the generation of nitrogen oxides and combustion noise as well as to reduce the generation of smoke and particulates during low-speed, high-load operation. In addition, since in terms of the engine the

fuel injection quantity can be increased under the same smoke conditions during low-speed, high-load operation, it is possible to realize improved low-speed torque and increased power output.

[0089] At the rated point during high-speed, high-load operation, on the other hand, the fuel injection pump 40 according to the first embodiment of the invention is able to maintain approximately the same relationship between the cam angle and the fuel injection rate ΔQ as when the prior art fuel injection pump 5 is used in combination with the ordinary prior art throttling type fuel injection nozzle 6.

[0090] Since it is further possible to hold down the injection rate during low-speed operation even when the fuel delivery rate is increased, output can be increased and fuel economy improved during high-speed, high-load operation by increasing the fuel injection rate (fuel delivery rate) accordingly.

[0091] Fig. 12 is a graph showing how the fuel injection quantity Q varies with engine speed N when the control rack 13 for controlling fuel injection quantity (Fig. 3) is immobilized. As shown, the N - Q characteristic curve can be made to decline to the left during low-speed, high-load operation.

[0092] Thus, by using a plunger 15 with a sub-port 42 exhibiting preflow effect and forming the upper sub-lead groove 47 at an appropriate position, the first embodiment of the invention is able to establish fuel injection advance during both high-speed operation and engine starting.

[0093] If it is desired to advance the fuel injection point during engine starting even more than during high-speed/high-load operation, it suffices to form the upper end 15A of the plunger 15 to be at a still higher position opposite the main port 41 and the sub-port 42 during engine starting.

[0094] As mentioned earlier, moreover, in addition to controlling the start of fuel injection it is further possible to control the fuel injection cutoff point through the combination of the lower main lead groove 44 and the lower sub-lead groove 48 with the main port 41 and the sub-port 42.

[0095] While a first embodiment was described in the foregoing, various other modifications are also capable of controlling both the start and end of fuel injection.

[0096] In each of the embodiments described in the following, the upper edge 41A of the main port 41 and the upper edge 42A of the sub-port 42 are at the same height or horizontal level, similarly to what is shown in Fig. 9. This point will not be mentioned again in the individual descriptions.

[0097] Fig. 13 is a simplified development, similar to that of Fig. 9, for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 50 which is a second embodiment. The upper end 15A of the plunger 15 and the upper sub-lead groove 47 are the same as those in the first embodiment shown in Fig.

9, but the slope of the lower sub-lead groove 48 is larger than in the case of the first embodiment, although still smaller than that of the lower main lead groove 44. With this configuration, fuel spills first from the sub-port 42 on both the low-load side and the high-load side.

[0098] In this second embodiment, since fuel spills first from the sub-port 42 on both the low-load side and the high-load side, the fuel injection rate can always be reduced on the low-speed side.

[0099] Fig. 14 is another simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 51 which does not form part of the invention. The upper end 15A of the plunger 15 and the upper sub-lead groove 47 are the same as those in the first embodiment shown in Fig. 9 and the second embodiment shown in Fig. 13, but, differently from in the first and second embodiments, the slope of the lower sub-lead groove 48 is larger than that of the lower main lead groove 44. With this configuration, fuel spills first from the sub-port 42 on the low-load side and spills first from main port 41 on the high-load side. Since fuel spills first from the sub-port 42 on the low-load side and spills first from the main port 41 on the high-load side, the fuel injection rate can be reduced during low-speed, low-load operation.

[0100] Fig. 15 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 52 which is a third embodiment. The upper end 15A of the plunger 15 and the upper sub-lead groove 47 are the same as those in the first embodiment shown in Fig. 9, the second embodiment shown in Fig. 13 but, differently from in the second embodiment, the slope of a lower main lead groove 53 corresponding to the lower main lead groove 44 and the slope of a lower sub-lead groove 54 corresponding to the lower sub-lead groove 48 are the same as in the first embodiment shown in Fig. 9.

[0101] On the other hand, a single vertical main passage 55 corresponding to the vertical main passage 43 is formed and only one end portion of each of the lower main lead groove 53 and the lower sub-lead groove 54 communicates with the vertical main passage 55.

[0102] Fig. 16 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 56 which is a fourth embodiment. The upper end 15A of the plunger 15 is formed with an inclined upper sub-lead groove 57 for communicating with the sub-port 42 on the low-load side. Since the inclined upper sub-lead groove 57 slopes in the opposite direction from the lower main lead groove 44 and the lower sub-lead groove 48, the fuel delivery start point can be controlled from the low-load side toward the high-load side such that, particularly on the low-speed side, it is more retarded on the low-load side.

[0103] The slopes of the lower sub-lead groove 48 and the lower main lead groove 44 are the same as

those in the first embodiment shown in Fig. 9, so that fuel spills first from the main port 41 on the low-load side and spills first from the sub-port 42 on the high-load side.

[0104] Fig. 17 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 58 which is a fifth embodiment. The upper end 15A of the plunger 15 and the upper sub-lead groove 57 are the same as those in the fifth embodiment shown in Fig. 16, but the slope of the lower sub-lead groove 48 is smaller than in the case of the fourth embodiment. With this configuration, fuel spills first from the sub-port 42 on both the low-load side and the high-load side.

[0105] Fig. 18 is another simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 59 which does not form part of the invention. The upper end 15A of the plunger 15 and the upper sub-lead groove 57 are the same as those in the fourth embodiment shown in Fig. 16 and the fifth embodiment shown in Fig. 17, but, differently from in the fourth and fifth embodiments, the slope of the lower sub-lead groove 48 is larger than that of the lower main lead groove 44. With this configuration, fuel spills first from the sub-port 42 on the low-load side and spills first from the main port 41 on the high-load side.

[0106] Fig. 19 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 60 which is an sixth embodiment. The upper end 15A of the plunger 15 is formed with an inclined upper sub-lead groove 61 for communicating with the sub-port 42 on the high-load side. Since the inclined upper sub-lead groove 61 slopes in the same direction as the lower main lead groove 44 and the lower sub-lead groove 48, the fuel delivery start point can be controlled from the low-load side toward the high-load side such that, particularly on the low-speed side, it is more retarded on the high-load side.

[0107] The slopes of the lower sub-lead groove 48 and the lower main lead groove 44 are the same as those in the first embodiment shown in Fig. 9, so that fuel spills first from the main port 41 on the low-load side and spills first from the sub-port 42 on the high-load side.

[0108] Fig. 20 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 62 which is a seventh embodiment. The upper end 15A of the plunger 15 and the upper sub-lead groove 61 are the same as those in the sixth embodiment shown in Fig. 19, but the slope of the lower sub-lead groove 48 is smaller than in the case of the sixth embodiment. With this configuration, fuel spills first from the sub-port 42 on both the low-load side and the high-load side.

[0109] Fig. 21 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 63 which does not

form part of the invention. The upper end 15A of the plunger 15 and the upper sub-lead groove 61 are the same as those in the sixth embodiment shown in Fig. 16 and the seventh embodiment shown in Fig. 20, but, differently from in the sixth and seventh embodiments, the slope of the lower sub-lead groove 48 is larger than that of the lower main lead groove 44. With this configuration, fuel spills first from the sub-port 42 on the low-load side and spills first from the main port 41 on the high-load side.

[0110] The effects as described above can be implemented in various other ways than described in the foregoing embodiments and, specifically, is able to achieve desired fuel injection characteristics by controlling the fuel injection start and cutoff times by appropriate selection of the slopes of the lower main lead groove 44 and the lower sub-lead groove 48 and the positions and slopes of the upper sub-lead groove (47, 57, 61) at the upper end 15A of the plunger 15.

[0111] Further embodiments will be explained with reference to Figs. 22 to 34. The fuel injection pump in these embodiments differs from the fuel injection pump as described in connection with the first through seventh embodiment in that it is provided with an upper main lead groove 46 (see Fig. 22 et seq.) in addition to the upper sub-lead groove 47.

[0112] An eighth embodiment of the fuel injection pump will first be explained with reference to Figs. 22 to 25.

[0113] Fig. 22 is a vertical sectional view of the fuel injection pump 70 and Fig. 23 is a vertical sectional view of an essential portion thereof.

[0114] Fig. 24 is a development of lead grooves at the head portion of a plunger 15 of the fuel injection pump 70, showing the positional relationship between the main port 41 and the sub-port 42 at engine starting (broken lines) and at low-load operation and high-load operation (solid lines).

[0115] As shown by Figs. 23 and 24, the peripheral surface of the plunger head is formed with a vertical main passage 43 communicating with the fuel chamber 21, an inclined lower main lead groove 44 communicating with the vertical main passage 43, a vertical sub-passage 45 communicating with the fuel chamber 21, an upper main lead groove 46 communicating with the fuel chamber 21, an upper sub-lead groove 47 also communicating with the fuel chamber 21, and an inclined lower sub-lead groove 48 communicating with the vertical sub-passage 45.

[0116] Since the lower main lead groove 44 and the lower sub-lead groove 48 are both formed at positions below the upper end 15A of the plunger 15, they control the time at which spilling of the pressurized fuel (delivery cutoff) occurs. This is the same as in the first through seventh embodiment.

[0117] The lower main lead groove 44 is formed to have a sharper slope than that of the lower sub-lead groove 48. Specifically, the lower main lead groove 44

and the lower sub-lead groove 48 are formed to slope in the direction from the low-load side to the high-load side and in the downward direction of the plunger 15 such that the slope of the lower main lead groove 44 is greater than that of the lower sub-lead groove 48.

[0118] As will be explained later with reference to other embodiments, however, the slopes of the lower main lead groove 44 and the lower sub-lead groove 48 can be suitably determined for appropriately selecting the fuel injection characteristics.

[0119] The region within which the main port 41 is opposite the upper main lead groove 46 and the sub-port 42 is opposite the upper sub-lead groove 47 corresponds to an engine load range extending from low load to high load. The region of the upper end 15A of the plunger 15 corresponds to the engine starting region.

[0120] Since the plunger 15 is reciprocated within the plunger barrel 14 by the cam 12, the upper main lead groove 46, the upper sub-lead groove 47, the lower sub-lead groove 48, the vertical main passage 43 and the lower main lead groove 44 move vertically together relative to the stationary main port 41 and sub-port 42. This is shown in Fig. 24.

[0121] As also shown in Fig. 24, since the plunger 15 is rotated relative to the plunger barrel 14 by the action of the control rack 13, the upper main lead groove 46, the upper sub-lead groove 47, the lower sub-lead groove 48, the vertical main passage 43 and the lower main lead groove 44 move laterally together relative to the stationary main port 41 and sub-port 42.

[0122] In the so-configured fuel injection pump 70, fuel is drawn into the fuel chamber 21 from the fuel reservoir 20 through the main port 41 and the sub-port 42 as the plunger 15 moves down.

[0123] As the plunger 15 rises, fuel pressurization starts from the point that the upper end 15A of the plunger 15, the upper edge 46A of the upper main lead groove 46 and the upper edge 47A of the upper sub-lead groove 47 close the main port 41 and the sub-port 42 and the delivery of pressurized fuel ends when the main port 41 is opened by the lower main lead groove 44 or when the sub-port 42 is opened by the lower sub-lead groove 48.

[0124] The part of the stroke of the plunger 15 from its bottom dead point to the start of fuel delivery is the prestroke and the part thereof from the closure of the sub-port 42 to the opening of the main port 41 is the effective stroke. Similarly to what is shown in Fig. 8 regarding the first embodiment of the invention, the depth (height) of the upper sub-lead groove 47 is the engine starting fuel injection advance level difference L1 with respect to low-speed operation. The depth (height) of the upper main lead groove 46 is the engine starting fuel injection advance level difference L2 with respect to high-speed operation and the difference between L1 and L2 (L1 - L2) is the prestroke.

[0125] More specifically, during engine starting neither the main port 41 nor the sub-port 42 is situated

opposite the upper main lead groove 46 or the upper sub-lead groove 47; both face the upper end 15A in the engine starting region of the plunger 15.

[0126] Since the effective stroke for fuel delivery is therefore maximum, the fuel injection quantity required for starting the engine can be secured.

[0127] Since the upper main lead groove 46 is formed such that the upper end 15A of the plunger 15 is located above the upper edge 46A of the upper main lead groove 46, fuel injection is more advanced during engine starting than during low-speed/low-load operation.

[0128] During low-load and high-load engine operation, the main port 41 can be brought opposite the upper main lead groove 46 and the sub-port 42 can be brought opposite the upper sub-lead groove 47.

[0129] During idling or other such low-speed, low-load operation, the main port 41 is positioned to the left of the lower main lead groove 44 as seen in Fig. 24. The effective stroke short is therefore short and, moreover, since the sub-port 42 is in communication with the upper sub-lead groove 47, substantial delivery of pressurized fuel starts from the closure of the sub-port 42 by the upper edge 47A of the upper sub-lead groove 47.

[0130] As the engine speed increases and a high-speed, low-load operating condition arises, the main port 41 remains to the left of the lower main lead groove 44 but the throttling effect of the sub-port 42 causes fuel delivery to start before the sub-port 42 is completely closed by the upper edge 47A of the upper sub-lead groove 47. As a result, fuel injection is advanced and the actual delivery stroke increased.

[0131] Fig. 25 is a timing map shown within an N-Q characteristic diagram.

[0132] As shown in this figure, an advance characteristic can be obtained both during engine starting and during high-speed operation.

[0133] As shown best in Fig. 24, the point at which fuel delivery starts is the same during both low-load operation and high-load operation. Regarding the point at which fuel delivery ends, however, on the low-load side fuel first spills from the main port 41 while on the high-load side fuel first spills from the sub-port 42.

[0134] On the high-load side, the part of the stroke of the plunger 15 after spill from the sub-port 42 up to the start of spill from the main port 41 is the sub-port spill stroke.

[0135] On the low-load side, at the time that the main port 41 begins to spill fuel owing to the movement (rise) of the plunger 15 in the direction of fuel delivery, the sub-port 42 has still not come into communication with the lower sub-lead groove 48. It is therefore possible to achieve approximately the same injection characteristic as in the prior art fuel injection pump.

[0136] On the high-load side, since the main port 41 has not yet come into communication with the lower main lead groove 44 at the time fuel begins to spill from the sub-port 42, fuel is spilled from the sub-port 42, par-

ticularly during low-speed operation.

[0137] During high-speed operation, it is possible to achieve approximately the same injection characteristic as in the prior art since the sub-port 42 is kept substantially closed by its throttling effect even after it comes into communication with the lower sub-lead groove 48.

[0138] As in the first embodiment of the invention and shown in Fig. 11, when the prior art fuel injection pump 5 (Fig. 3) is used in combination with an ordinary prior art throttling type fuel injection nozzle 6 (Fig. 4), the relationship between the cam speed and the fuel injection rate ΔQ at the torque point during low-speed, high-load operation exhibits a steep point (the protruding maximum fuel injection rate of the solid line curve), whereas, as can be seen from the broken-line curve, the fuel injection pump 70 according to the eighth embodiment of the invention exhibits a flatter curve and greatly reduces the maximum fuel injection rate.

[0139] In other words, during low-speed, high-load operation, fuel is slowly spilled from midway through the effective stroke in the course of the rise of the plunger 15 owing to the opening of the sub-port 42 by the lower sub-lead groove 48, and the resulting lowering of the fuel delivery rate during low-speed operation makes it possible to reduce the generation of nitrogen oxides and combustion noise as well as to reduce the generation of smoke and particulates during low-speed, high-load operation. In addition, since in terms of the engine the fuel injection quantity can be increased under the same smoke conditions during low-speed, high-load operation, it is possible to realize improved low-speed torque and increased power output.

[0140] At the rated point during high-speed, high-load operation, on the other hand, the fuel injection pump 70 according to the eighth embodiment of the invention is able to maintain approximately the same relationship between the cam angle and the fuel injection rate ΔQ as when the prior art fuel injection pump 5 is used in combination with the ordinary prior art throttling type fuel injection nozzle 6.

[0141] Since it is further possible to hold down the injection rate during low-speed operation even when the fuel delivery rate is increased, output can be increased and fuel economy improved during high-speed, high-load operation by increasing the fuel injection rate (fuel delivery rate) accordingly.

[0142] As in the first through seventh embodiment and shown in Fig. 12, the N-Q characteristic curve can be made to decline to the left during low-speed, high-load operation.

[0143] Thus, by using a plunger 15 with a sub-port 42 exhibiting preflow effect and forming the upper sub-lead groove 47 at an appropriate position, the eighth embodiment of the invention is able to establish fuel injection advance during both high-speed operation and engine starting.

[0144] If it is desired to advance the fuel injection point during engine starting even more than during

high-speed/high-load operation, it suffices to form the upper end 15A of the plunger 15 to be at a still higher position opposite the main port 41 and the sub-port 42 during engine starting.

[0145] As mentioned earlier, moreover, in addition to controlling the start of fuel injection it is further possible to control the fuel injection cutoff point through the combination of the lower main lead groove 44 and the lower sub-lead groove 48 with the main port 41 and the sub-port 42.

[0146] While an eighth embodiment was described in the foregoing, various other modifications also capable of controlling both the start and end of fuel injection.

[0147] In each of the embodiments eight to fifteen described in the following, the upper edge 41A of the main port 41 and the upper edge 42A of the sub-port 42 are at the same height or horizontal level, similarly to what is shown in Fig. 24. This point will not be mentioned again in the individual descriptions.

[0148] Fig. 26 is a simplified development, similar to that of Fig. 24, for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 71 which is a ninth embodiment. The upper end 15A of the plunger 15 and the upper sub-lead groove 47 are the same as those in the eighth embodiment shown in Fig. 24, but, similarly to the third embodiment (Fig. 15), the slope of a lower main lead groove 53 corresponding to the lower main lead groove 44 and the slope of a lower sub-lead groove 54 corresponding to the lower sub-lead groove 48 are the same as in the eighth embodiment shown in Fig. 24.

[0149] On the other hand, a single vertical main passage 55 corresponding to the vertical main passage 43 is formed and only one end portion of each of the lower main lead groove 53 and the lower sub-lead groove 54 communicates with the vertical main passage 55.

[0150] Fig. 27 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 72 which is a tenth embodiment. The upper end 15A of the plunger 15 is formed with an inclined upper sub-lead groove 73 for communicating with the sub-port 42 on the low-load side and the high-load side. Since the upper sub-lead groove 73 slopes in the opposite direction from the lower main lead groove 44 and the lower sub-lead groove 48, the fuel delivery start point can be controlled from the low-load side toward the high-load side such that, particularly on the low-speed side, it is more retarded on the low-load side.

[0151] The slopes of the lower sub-lead groove 48 and the lower main lead groove 44 are the same as those in the eighth embodiment shown in Fig. 24, so that fuel spills first from the main port 41 on the low-load side and spills first from the sub-port 42 on the high-load side.

[0152] Fig. 28 is a simplified development for explaining lead grooves at the head portion of the

plunger 15 of a fuel injection pump 74 which is a eleventh embodiment. The upper end 15A of the plunger 15 and the upper sub-lead groove 73 are the same as those in the tenth embodiment shown in Fig. 27 but the lower main lead groove 44 is formed at a lower portion of the plunger 15 than in the tenth embodiment. With this configuration, fuel spills first from the sub-port 42 on both the low-load side and the high-load side.

[0153] Fig. 29 is another simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 75 which does not form part of the invention. The upper end 15A of the plunger 15 and the upper sub-lead groove 73 are the same as those in the tenth embodiment shown in Fig. 27 and the eleventh embodiment shown in Fig. 28, but, differently from in the tenth and eleventh embodiments, the slope of the lower sub-lead groove 48 is larger than that of the lower main lead groove 44. With this configuration, fuel spills first from the sub-port 42 on the low-load side and spills first from the main port 41 on the high-load side.

[0154] Fig. 30 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 76 which is a twelfth embodiment. The upper end 15A of the plunger 15 is formed with an inclined upper main lead groove 77 for communicating with the main port 41 on the high-load side. Since the upper main lead groove 77 slopes in the same direction as the lower main lead groove 44 and the lower sub-lead groove 48, the fuel delivery start point can be controlled from the low-load side toward the high-load side such that it is more retarded on the high-load side.

[0155] The slopes of the lower sub-lead groove 48 and the lower main lead groove 44 are the same as those in the eighth embodiment shown in Fig. 24, so that fuel spills first from the main port 41 on the low-load side and spills first from the sub-port 42 on the high-load side.

[0156] Fig. 31 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 78 which is a thirteenth embodiment. The upper end 15A of the plunger 15 and the upper main lead groove 77 are the same as those in the twelfth embodiment shown in Fig. 30 but the lower sub-lead groove 48 is formed at a higher portion of the plunger 15 than in the twelfth embodiment. With this configuration, fuel spills first from the sub-port 42 on both the low-load side and the high-load side.

[0157] Fig. 32 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 79 which does not form part of the invention. The upper end 15A of the plunger 15 and the upper main lead groove 77 are the same as those in the twelfth embodiment shown in Fig. 30 and the thirteenth embodiment shown in Fig. 31, but, differently from in the twelfth and thirteenth embodiments, the slope of the lower sub-lead groove 48 is

larger than that of the lower main lead groove 44. With this configuration, fuel spills first from the sub-port 42 on the low-load side and spills first from the main port 41 on the high-load side.

[0158] Fig. 33 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 80 which is a fourteenth embodiment. The upper end 15A of the plunger 15 is formed with an inclined upper sub-lead groove 81 for communicating with the sub-port 42 on the low-load side and the high-load side. Since the upper sub-lead groove 81 slopes in the same direction as the lower main lead groove 44 and the lower sub-lead groove 48, the fuel delivery start point can be controlled from the low-load side toward the high-load side such that, particularly on the low-speed side, it is more retarded on the high-load side.

[0159] The slopes of the lower sub-lead groove 48 and the lower main lead groove 44 are the same as those in the eighth embodiment shown in Fig. 24, so that fuel spills first from the main port 41 on the low-load side and spills first from the sub-port 42 on the high-load side.

[0160] Fig. 34 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 82 which is a fifteenth embodiment. The upper end 15A of the plunger 15 is formed with an inclined upper main lead groove 83 for communicating with the main port 41 on the low-load side and the high-load side. Since the upper main lead groove 83 slopes in the opposite direction from the lower main lead groove 44 and the lower sub-lead groove 48, the fuel delivery start point can be controlled from the low-load side toward the high-load side such that it is more retarded on the low-load side.

[0161] The slopes of the lower sub-lead groove 48 and the lower main lead groove 44 are the same as those in the eighth embodiment shown in Fig. 24, so that fuel spills first from the main port 41 on the low-load side and spills first from the sub-port 42 on the high-load side.

[0162] Various other ways than described in the foregoing embodiments are possible specifically, if they are able to achieve desired fuel injection characteristics by controlling the fuel injection start and cutoff times by appropriate selection of the slopes of the lower main lead groove 44 and the lower sub-lead groove 48, and the positions and slopes of the upper main lead groove (46, 77, 83) the upper sub-lead groove (47, 57, 81) at the upper end 15A of the plunger 15.

[0163] Further embodiments sixteen to twenty will be explained with reference to Figs. 35 to 41. The fuel injection pump according to these embodiments is similar to the fuel injection pumps according to the first through fifteenth embodiment in the point that it is provided with the lower main lead groove 44 and the lower sub-lead groove 48, but differently therefrom, is configured specifically for use with a throttling type fuel injection pump.

tion nozzle 6 (Fig. 4) provided in an auxiliary combustion chamber of a divided-chamber combustion system diesel engine (e.g., in the auxiliary combustion chamber 4 of Fig. 1 or the swirl chamber 9 of Fig. 2).

[0164] A fuel injection pump 90 which is a sixteenth embodiment will now be explained with reference to the drawings.

[0165] Fig. 35 is an enlarged sectional view of an essential portion of the plunger barrel 14 and the plunger 15 of the fuel injection pump 90 and Fig. 36 is a development of lead grooves at the head portion of the plunger 15. As in the fuel injection pumps according to the aforementioned embodiments, the plunger barrel 14 is formed with a large-diameter main port 41 and a small diameter sub-port 42 which together serve the purpose of the feed hole 22 of the prior art fuel injection pump (Fig. 3).

[0166] The upper edge 41A of the main port 41 and the upper edge 42A of the sub-port 42 are at the same height or horizontal level. They are formed over an interval of 180 degrees in the circumferential direction.

[0167] If necessary, the upper edge 41A of the main port 41 can instead be located at a higher level than the upper edge 42A of the sub-port 42.

[0168] The peripheral surface of the plunger head is formed with a vertical main passage 43 corresponding to the vertical passage 24 and communicating with the fuel chamber 21, a lower main lead groove 44 corresponding to the inclined lead groove 25 and communicating with the vertical main passage 43, a vertical sub-passage 45 corresponding to the vertical passage 24 and communicating with the fuel chamber 21, and a lower sub-lead groove 48 communicating with the vertical sub-passage 45.

[0169] Since the lower main lead groove 44 and the lower sub-lead groove 48 are both formed at positions below the upper end 15A of the plunger 15, they control the time at which spilling of the pressurized fuel (delivery cutoff) occurs.

[0170] The lower main lead groove 44 is formed to have a sharper slope than that of the lower sub-lead groove 48. Specifically, the lower main lead groove 44 and the lower sub-lead groove 48 are formed to slope in the direction from the low-load side to the high-load side and in the downward direction of the plunger 15 such that the slope of the lower main lead groove 44 is greater than that of the lower sub-lead groove 48.

[0171] Since the plunger 15 is reciprocated within the plunger barrel 14 by the cam 12 (Fig. 3), the vertical main passage 43, the lower main lead groove 44, the vertical sub-passage 45 and the lower sub-lead groove 48 move vertically together relative to the stationary main port 41 and sub-port 42. This is shown in Fig. 36.

[0172] As also shown in Fig. 36, since the plunger 15 is rotated relative to the plunger barrel 14 by the action of the control rack 13 (Fig. 3), the vertical main passage 43, the lower main lead groove 44, the vertical sub-passage 45 and the lower sub-lead groove 48 move

laterally together relative to the stationary main port 41 and sub-port 42.

[0173] Therefore, as shown by hatching in Fig. 36, if the zone within which fuel spills from the sub-port 42 is represented at the position of the main port 41, it appears between the upper edge 48A of the lower sub-lead groove 48 and the upper edge 44A of the lower main lead groove 44 as a triangular zone above the lower main lead groove 44.

[0174] Fig. 37 is a simplified explanatory view derived from Fig. 36. The left side of the figure corresponds to low-load operation and the right side to high-load operation. The positions of the main port 41 and the sub-port 42 during high-load operation are shown in solid lines and the positions thereof during low-load operation are shown in broken lines.

[0175] As best shown in Fig. 37, in the fuel injection pump 90 of the foregoing configuration the point at which fuel delivery starts is the same during both low-load operation and high-load operation. Regarding the point at which fuel delivery ends, however, on the low-load side fuel first spills from the main port 41 while on the high-load side fuel first spills from the sub-port 42.

[0176] On the low-load side, at the time that the main port 41 begins to spill fuel owing to the movement (rise) of the plunger 15 in the direction of fuel delivery, the sub-port 42 has still not come into communication with the lower sub-lead groove 48. It is therefore possible to achieve approximately the same injection characteristic as in the prior art fuel injection pump.

[0177] On the high-load side, since the main port 41 has not yet come into communication with the lower main lead groove 44 at the time fuel begins to spill from the sub-port 42, fuel is spilled from the sub-port 42, particularly during low-speed operation.

[0178] During high-speed operation, it is possible to achieve approximately the same injection characteristic as in the prior art since the sub-port 42 is kept substantially closed by its throttling effect even after it comes into communication with the lower sub-lead groove 48.

[0179] As in the first through fifteenth embodiment and shown in Fig. 11, when the prior art fuel injection pump 5 (Fig. 3) is used in combination with an ordinary prior art throttling type fuel injection nozzle 6 (Fig. 4), the relationship between the cam speed and the fuel injection rate ΔQ at the torque point during low-speed, high-load operation exhibits a steep point (the protruding maximum fuel injection rate of the solid line curve), whereas, as can be seen from the broken-line curve, the fuel injection pump 90 according to the sixteenth embodiment exhibits a flatter curve and greatly reduces the maximum fuel injection rate.

[0180] In other words, during low-speed, high-load operation, fuel is slowly spilled from midway through the effective stroke in the course of the rise of the plunger 15 owing to the opening of the sub-port 42 by the lower sub-lead groove 48, and the resulting lowering of the fuel delivery rate during low-speed operation makes it

possible to reduce the generation of nitrogen oxides and combustion noise as well as to reduce the generation of smoke and particulates during low-speed, high-load operation. In addition, since in terms of the engine the fuel injection quantity can be increased under the same smoke conditions during low-speed, high-load operation, it is possible to realize improved low-speed torque and increased power output.

[0181] At the rated point during high-speed, high-load operation, on the other hand, the fuel injection pump 90 according to the third aspect of the invention is able to maintain approximately the same relationship between the cam angle and the fuel injection rate ΔQ as when the prior art fuel injection pump 5 is used in combination with the ordinary prior art throttling type fuel injection nozzle 6.

[0182] Since it is further possible to hold down the injection rate during low-speed operation even when the fuel delivery rate is increased, output can be increased and fuel economy improved during high-speed, high-load operation by increasing the fuel injection rate (fuel delivery rate) accordingly.

[0183] As in the first through fifteenth embodiment and as shown in Fig. 12, the N-Q characteristic curve can be made to decline to the left during low-speed, high-load operation.

[0184] The sixteenth embodiment controls fuel delivery cutoff. Although in the foregoing description of the sixteenth embodiment invention an example was given in which the start of fuel delivery is achieved by simultaneously closing the main port 41 and the sub-port 42 with the upper end 15A of the plunger 15, various other modifications such as those set out below are also possible.

[0185] Fig. 38 is a simplified development, similar to that of Fig. 37, for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 90 which is a seventeenth embodiment. The main port 41 is provided above the sub-port 42 and the upper end 15A of the plunger 15 is left flat. With this configuration, the sub-port 42 is closed first and the main port 41 is closed thereafter.

[0186] In this seventeenth embodiment and all of the other embodiments described hereinafter, the fuel delivery cutoff point is determined in the same manner as in the first embodiment, namely by spilling fuel first from the main port 41 on the low-load side and first from the sub-port 42 on the high-load side.

[0187] In the seventeenth embodiment, the sub-port 42 is closed at all times that the main port 41 is closed by the upper end 15A of the plunger 15. Therefore, as regards the start of fuel delivery it is possible to obtain the same injection characteristics as in the case of the sub-port 42 not being provided.

[0188] Fig. 39 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 92 which is an eighteenth embodiment. The main port 41 and the sub-port

42 are formed at the same level, an upper sub-lead groove 93 is provided in the plunger 15 at the rotational position thereof which can be brought opposite the sub-port 42, and the upper end 15A at the rotational position of the plunger 15 which can be brought opposite the main port 41 is left flat. With this configuration, the main port 41 is closed first and the sub-port 42 is closed thereafter.

[0189] In the eighteenth embodiment, fuel is delivered before the feed ports are closed (particularly before the sub-port 42 is closed) during high-speed operation owing to the preflow effect (dynamic effect or throttling effect). As result, a fuel injection timing advance characteristic can be obtained during high-speed operation, under both high-load and low-load.

[0190] Fig. 40 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 94 which is a nineteenth embodiment. The main port 41 and the sub-port 42 are formed at the same level, the upper sub-lead groove 93 is provided in the plunger 15 at the rotational position thereof which can be brought opposite the sub-port 42 (similarly to the case of Fig. 39), the rotational position of the plunger 15 which is brought opposite the main port 41 during low-load operation being left as the flat upper end 15A and the rotational position thereof brought opposite the main port 41 during high-load operation being formed with an inclined upper main lead groove 95 which slopes in the same direction as the lower main lead groove 44 and the lower sub-lead groove 48.

[0191] In the nineteenth embodiment, during low-load operation the main port 41 closes first and the sub-port 42 closes thereafter, while during high-load operation the sub-port 42 closes first and the main port 41 closes thereafter. Since the portion of the inclined upper main lead groove 95 which communicates with the main port 41 varies depending on the degree of load between the low and high sides, it is possible to establish a fuel injection characteristic wherein the fuel injection time point is advanced during high-speed operation at low load and is gradually retarded as the load increases.

[0192] Fig. 41 is a simplified development for explaining lead grooves at the head portion of the plunger 15 of a fuel injection pump 96 which is a twentieth embodiment. The main port 41 and the sub-port 42 are formed at the same level, a vertical main passage 97 corresponding to the vertical main passage 43 is formed at the center, and the vertical main passage 97 is provided on its right (as seen in Fig. 41) with a lower main lead groove 98 formed at the rotational position of the plunger 15 which can be brought opposite the main port 41 and on its left with a lower sub-lead groove 99 formed at the rotational position of the plunger 15 which can be brought opposite the sub-port 42. As in the sixteenth embodiment shown in Fig. 36, the sub-port 42 and the main port 41 are simultaneously closed by the upper end 15A of the plunger 15.

[0193] While the fuel injection characteristics obtained with the twentieth embodiment are substantially the same as those of the sixteenth embodiment (Fig. 37), the strength of the plunger 15 is more reliably secured since the configuration enables the lower main lead groove 98 and the lower sub-lead groove 99 to use the vertical main passage 97 in common.

[0194] Since the fuel injection pump utilizes the pre-flow effect obtained by the provision of a sub-port and an upper sub-lead groove and is formed with a lower main lead groove and a lower sub-lead groove whose slopes can be selected in an appropriate combination, it is possible to maintain a speed timer capability enabling control of the fuel injection timing during low- and high-speed operation while at the same time achieving a reduction in the generation of black smoke and particulates, particularly during low-speed, high-load operation, and also achieving an increase in fuel injection quantity that results in higher torque.

[0195] Since the fuel injection pump utilizes the pre-flow effect obtained by the provision of a sub-port and an upper sub-lead groove, is formed with a lower main lead groove and a lower sub-lead groove whose slopes can be selected in an appropriate combination and is formed with an upper main lead groove which can communicate with the main port, it is possible to maintain a speed timer capability enabling control of the fuel injection timing during low- and high-speed operation and a fuel injection time advance capability during engine starting while at the same time achieving a reduction in the generation of black smoke and particulates, particularly during low-speed, high-load operation, and also achieving an increase in fuel injection quantity that results in higher torque.

[0196] Moreover, since the fuel injection pumps according to the first through fifteenth embodiment make it possible to increase fuel delivery without increasing the fuel injection rate during low-speed operation, they enable an increase in the fuel injection rate (fuel delivery rate) during high-speed, high-load operation as well as an increase in power output and an improvement in fuel economy.

[0197] Since the fuel injection pump is used in combination with a throttling type fuel injection nozzle, has a main port and a sub-port formed in the plunger barrel, has a lower main lead groove and a lower sub-lead groove formed in the plunger, and is configured to enable fuel to spill first from the sub-port on the high-load side and to spill first from the main port on the low load side, it is able to reduce the maximum fuel injection rate on the low-speed, high-load side, thereby reducing the generation of smoke in this operating region.

Claims

1. A fuel injection pump comprising:

a pump housing (10) formed with a fuel reser-

voir (20),

a plunger barrel (14) mounted in the pump housing (10) having a larger diameter main feed port (41) and a smaller diameter sub-feed port (42) which communicate with the fuel reservoir (20), the upper edge (42A) of the sub-feed port (42) lying below the upper edge (41A) of the main feed port (41) or at the same height,

a plunger (15) accommodated in the plunger barrel (14) capable of sliding reciprocation and rotation therein and being formed with an inclined lower main lead groove (44;53) spaced apart from an upper end portion (15A) of the plunger (15) at a position for communication with the main feed port (41), and

a fuel chamber (21) formed between the plunger (15) and the plunger barrel (14) wherein upon reciprocation of the plunger (15) fuel is sucked into the fuel chamber (21) from the fuel reservoir (20) and further delivered under pressure to a fuel injection nozzle (6), wherein the head portion of the plunger (15) is formed with an upper sub-lead groove (47;57;61;73;81) capable of communicating with the sub-feed port (42) over a prescribed rotational range of the plunger (15) and of maintaining communication with the sub-feed port (42) even when the main feed port (41) is closed by the upper end portion (15A) of the plunger (15),

the plunger (15) is provided over a prescribed rotational range of its circumference with an inclined lower sub-lead groove (48;54) spaced apart from the upper end portion (15A) of the plunger (15) and capable of communicating with the sub-feed port (42), said lower sub-lead groove (48;54) being formed also below the upper end portion (15A) of the plunger, wherein the lower main lead groove (44;53) and the lower sub-lead groove (48;54) are formed to slope in the direction from low-load side to high-load side and in the downward direction of the plunger (15),

characterized in that

at the rotational position of the plunger (15) during high-load operation the main feed port (41) does not communicate with the lower main lead groove (44;53) even when the sub-feed port (42) comes into communication with the lower sub-lead groove (48;54) owing to movement of the plunger (15) in the fuel delivery direction and the slope of the lower main lead groove (44;53) is greater than that of the lower sub-lead groove (48;54).

2. A fuel injection pump according to claim 1, wherein at the rotational position of the plunger (15) during

- low-load operation the sub-feed port (42) does not communicate with the lower sub-lead groove (48;54) even when the main feed port (41) comes into communication with the lower main lead groove (44;53) owing to movement of the plunger (15) in the fuel delivery direction. 5
3. A fuel injection pump according to claim 1, wherein the plunger (15) is formed with a vertical passage (43;45;55) capable of communicating with the fuel chamber (21), the lower main lead groove (44;53) and the lower sub-lead groove (48;54). 10
 4. A fuel injection pump according to claim 1, wherein the positions at which the main feed port (41) and the sub-feed port (42) are opposite the lower main lead groove (44;53) and the lower sub-lead groove (48;54) decline progressively in a downward sloping direction on the plunger (15) in the order of positions corresponding to low-load operation, high-load operation and starting. 15 20
 5. A fuel injection pump according to claim 1, wherein at starting the sub-feed port (42) is positioned opposite the upper end portion (15A) of the plunger (15) not formed with the upper sub-lead groove (47;57;61;73;81). 25
 6. A fuel injection pump according to claim 1, wherein at the rotational position of the plunger (15) during both high-load operation and low-load operation the main feed port (41) does not communicate with the lower main lead groove (44;53) even when the sub-feed port (42) comes into communication with the lower sub-lead groove (48;54) owing to movement of the plunger (15) in the fuel delivery direction. 30 35
 7. A fuel injection pump according to claim 3, wherein the vertical passage (55) is utilized in common by the lower main lead groove (53) and the lower sub-lead groove (54). 40
 8. A fuel injection pump according to claim 1, wherein an upper sub-lead groove (57;73) is formed in the upper end portion (15A) of the plunger (15) in an inclined manner capable of communicating with the sub-feed port (42) during low-load operation and sloping in the opposite direction from the lower main lead groove (44) and the lower sub-lead groove (48). 45 50
 9. A fuel injection pump according to claim 1, wherein an upper sub-lead groove (61) is formed in the upper end portion (15A) of the plunger (15) in an inclined manner capable of communicating with the sub-feed port (42) during high-load operation and sloping in the same direction as the lower main lead groove (44) and the lower sub-lead groove (48). 55
 10. A fuel injection pump according to one of claims 1 to 9, **characterized in that** the upper end portion (15A) of the plunger (15) further comprises an upper main lead groove (46;77;83) capable of communicating with the main feed port (41) over a prescribed rotational range of the plunger (15), the upper sub-lead groove (47;73;81) and the upper main lead groove (46;77;83) being formed such that within the prescribed rotational range of the plunger (15) the sub-feed port (42) is capable of maintaining communication with the upper sub-lead groove (47;73;81) even when the main feed port (41) is closed by the upper edge (46A) of the upper main lead groove (46;77;83), so that when the plunger (15) is in its rotational position at the starting operation the main feed port (41) is closable by the upper end portion (15A) of the plunger (15) not formed with the upper main lead groove (46;77;83) and the sub-feed port (42) is closable by the upper end portion (15A) of the plunger (15) not formed with the upper sub-lead groove (47;73;81).
 11. A fuel injection pump according to claim 10, wherein an upper sub-lead groove (73) is formed in the upper end portion (15A) of the plunger (15) in an inclined manner capable of communicating with the sub-feed port (42) during low-load operation and high-load operation and sloping in the opposite direction from the lower main lead groove (44) and the lower sub-lead groove (48).
 12. A fuel injection pump according to claim 10, wherein an upper main lead groove (77) is formed in the upper end portion (15A) of the plunger (15) in an inclined manner to be capable of communicating with the main feed port (41) during low-load operation and high-load operation, the upper main lead groove (77) sloping in the same direction as the lower main lead groove (44) and the lower sub-lead groove (48).
 13. A fuel injection pump according to claim 10, wherein an upper sub-lead groove (81) is formed in the upper end portion (15A) of the plunger (15) in an inclined manner capable of communicating with the sub-feed port (42) during low-load operation and high-load operation and sloping in the same direction as the lower main lead groove (44) and the lower sub-lead groove (48).
 14. A fuel injection pump according to claim 10, wherein an upper main lead groove (83) is formed in the upper end portion (15A) of the plunger (15) in an inclined manner capable of communicating with the main feed port (41) during low-load operation and high-load operation and sloping in the opposite direction from the lower main lead groove (44) and the lower sub-lead groove (48).

15. A combination of a fuel injection pump and an injection nozzle, said combination comprising:

a pump housing (10) formed with a fuel reservoir (20),
 a plunger barrel (14) mounted in the pump housing (10) having a larger diameter main feed port (41) and a smaller diameter sub-feed port (42) which communicate with the fuel reservoir (20),
 a plunger (15) accommodated in the plunger barrel (14) capable of sliding reciprocation and rotation therein and being formed with an inclined lower main lead groove (44;98) spaced apart from an upper end portion (15A) of the plunger (15) at a position for communication with the main feed port (41), and
 a fuel chamber (21) formed between the plunger (15) and the plunger barrel (14) wherein upon reciprocation of the plunger (15) fuel is sucked into the fuel chamber (21) from the fuel reservoir (20) and further delivered under pressure to a fuel injection nozzle (6), wherein the plunger (15) is provided over a prescribed rotational range of its circumference with an inclined lower sub-lead groove (48;99) spaced apart from the upper end portion (15A) of the plunger (15) and capable of communicating with the sub-feed port (42), said lower sub-lead groove (48;99) being formed below the upper end portion (15A) of the plunger (15),
characterized in that
 the fuel injection nozzle (6) is a throttling type fuel injection nozzle (6) adapted for injection in an auxiliary combustion chamber (4,9) of a divided-chamber combustion system diesel engine, and
 wherein at the rotational position of the plunger (15) during high-load operation the main feed port (41) does not communicate with the lower main lead groove (44;98) even when the sub-feed port (42) comes into communication with the lower sub-lead groove (48;99) owing to movement of the plunger (15) in the fuel delivery direction and the slope of the lower main lead groove (44;98) is greater than that of the lower sub-lead groove (48;99), and
 wherein at the rotational position of the plunger (15) during low-load operation, the sub-feed port (42) does not communicate with the lower sub-lead groove (48;99) even when the main feed port (41) comes into communication with the lower main lead groove (44;98) owing to movement of the plunger (15) in the fuel delivery direction.

16. A combination of a fuel injection pump and an injection nozzle according to claim 15, wherein the fuel

injection nozzle (6) comprises:

a nozzle body (26) formed at its tip with a nozzle hole (37) having a cylindrical wall portion (37A) and a seat portion (37B), and
 a needle valve (30) slidable within the nozzle body (26) for opening and closing the nozzle hole (37) and whose tip portion is constituted of a pin member (30A) and a tapered portion (30B),
 said pin member (30A) being disposed opposite said cylindrical wall portion (37A) and said tapered portion (30B) being disposed opposite the seat portion (37B).

17. A combination of a fuel injection pump and an injection nozzle according to claim 15, wherein an upper edge (42A) of the sub-feed port (42) does not lie higher than an upper edge (41A) of the main feed port (41).
18. A combination of a fuel injection pump and an injection nozzle according to claim 15, wherein the plunger (15) is formed with a vertical passage (43,45;97) capable of communicating with the fuel chamber (21), the lower main lead groove (44;98) and the lower sub-lead groove (48;99).
19. A combination of a fuel injection pump and an injection nozzle according to claim 18, wherein the vertical passage (97) is utilized in common by the lower main lead groove (98) and the lower sub-lead groove (99).
20. A combination of a fuel injection pump and an injection nozzle according to claim 15, wherein the lower main lead groove (44;98) and the lower sub-lead groove (48;99) are formed to slope in the direction from low-load side to high-load side and in the downward direction of the plunger (15).
21. A combination of a fuel injection pump and an injection nozzle according to claim 15, wherein the upper end (15A) of the plunger (15) is formed with an upper main lead groove (95) capable of communicating with the main feed port (41) during high-load operation and sloping in the same direction from the lower main lead groove (44) and the lower sub-lead groove (48).

Patentansprüche

1. Kraftstoffeinspritzpumpe, die umfaßt:

ein Pumpengehäuse (10), das mit einem Kraftstoffbehälter (20) versehen ist,

eine Kolbenhülse (14), die in dem Pumpenge-

häuser (10) angebracht ist und eine Haupt-Zuführöffnung (41) mit größeren Durchmesser sowie eine Neben-Zuführöffnung (42) mit kleineren Durchmesser aufweist, die mit dem Kraftstoffbehälter (20) in Verbindung stehen, wobei die Oberkante (42A) der Neben-Zuführöffnung (42) unter der Oberkante (41A) der Haupt-Zuführöffnung (41) oder auf der gleichen Höhe liegt,

einen Kolben (15), der in der Kolbenhülse (14) aufgenommen ist und darin hin und her verschoben und gedreht werden kann und der mit einer geneigten unteren Haupt-Leitnut (44; 53) versehen ist, die von einem oberen Endabschnitt (15A) des Kolbens (15) an einer Position zur Herstellung von Verbindung mit der Haupt-Zuführöffnung (41) beabstandet angeordnet ist, sowie eine Kraftstoffkammer (21), die zwischen dem Kolben (15) und der Kolbenhülse (14) ausgebildet ist, wobei bei Hin- und Herbewegung des Kolbens (15) Kraftstoff aus dem Kraftstoffbehälter (20) in die Kraftstoffkammer (21) angesaugt wird und weiter unter Druck einer Kraftstoffeinspritzdüse (6) zugeführt wird, wobei der Kopfabchnitt des Kolbens (15) mit einer oberen Neben-Leitnut (47; 57; 61; 73; 81) versehen ist, die über einen vorgeschriebenen Drehbereich des Kolbens (15) mit der Neben-Zuführöffnung (42) in Verbindung treten kann und Verbindung mit der Neben-Zuführöffnung (42) auch dann aufrechterhalten kann, wenn die Haupt-Zuführöffnung (41) durch den oberen Endabschnitt (15A) des Kolbens (15) verschlossen wird, wobei der Kolben (15) über einen vorgeschriebenen Drehbereich seines Umfangs mit einer geneigten unteren Neben-Leitnut (48; 54) versehen ist, wobei der Kolben (15) über einen vorgeschriebenen Drehbereich seines Umfangs mit einer geneigten unteren Neben-Leitnut (48; 54) versehen ist, die vom oberen Endabschnitt (15A) des Kolbens (15) beabstandet angeordnet ist und mit der Neben-Zuführöffnung (42) in Verbindung treten kann, wobei die untere Neben-Leitnut (48; 54) auch unter dem oberen Endabschnitt (15A) des Kolbens (15) ausgebildet ist, wobei die untere Haupt-Leitnut (44; 53) und die untere Neben-Leitnut (48; 54) so ausgebildet sind, daß sie in der Richtung von der Niedriglastseite zur Hochlastseite und in der Abwärtsrichtung des Kolbens (15) geneigt sind, **dadurch gekennzeichnet**, daß:

an der Drehposition des Kolbens (15) bei Hochlastbetrieb die Haupt-Zuführöffnung (41) auch dann nicht mit der unteren Haupt-Leitnut

(44; 53) in Verbindung steht, wenn die Neben-Zuführöffnung (42) mit der unteren Neben-Leitnut (48; 54) aufgrund der Bewegung des Kolbens (15) in der Kraftstoffabgaberichtung in Verbindung tritt, und die Neigung der unteren Haupt-Leitnut (44; 53) größer ist als die der unteren Neben-Leitnut (48; 54).

2. Kraftstoffeinspritzpumpe nach Anspruch 1, wobei an der Drehposition des Kolbens (15) bei Niedriglastbetrieb die Neben-Zuführöffnung (42) auch dann nicht mit der unteren Neben-Leitnut (48; 54) in Verbindung steht, wenn die Haupt-Zuführöffnung (41) mit der unteren Haupt-Leitnut (44; 53) aufgrund der Bewegung des Kolbens (15) in der Kraftstoffabgaberichtung in Verbindung tritt.
3. Kraftstoffeinspritzpumpe nach Anspruch 1, wobei der Kolben (15) mit einem vertikalen Kanal (43, 45; 55) versehen ist, der mit der Kraftstoffkammer (21), der unteren Haupt-Leitnut (44; 53) und der unteren Neben-Leitnut (48; 54) in Verbindung treten kann.
4. Kraftstoffeinspritzpumpe nach Anspruch 1, wobei die Positionen, an denen die Haupt-Zuführöffnung (41) und die Neben-Zuführöffnung (42) der unteren Haupt-Leitnut (44; 53) und der unteren Neben-Leitnut (48; 54) gegenüberliegen, in einer Abwärtsneigungsrichtung an dem Kolben (15) in der Reihenfolge der Positionen, die Niedriglastbetrieb, Hochlastbetrieb und Anlassen entsprechen, zunehmend abfallen.
5. Kraftstoffeinspritzpumpe nach Anspruch 1, wobei beim Anlassen die Neben-Zuführöffnung (42) dem oberen Endabschnitt (15A) des Kolbens (15) gegenüberliegt, der nicht mit der oberen Neben-Leitnut (47; 57; 61; 73; 81) versehen ist.
6. Kraftstoffeinspritzpumpe nach Anspruch 1, wobei an der Drehposition des Kolbens (15) sowohl beim Hochlastbetrieb als auch beim Niedriglastbetrieb die Haupt-Zuführöffnung (41) auch dann nicht mit der unteren Haupt-Leitnut (44; 53) in Verbindung steht, wenn die Neben-Zuführöffnung (42) aufgrund der Bewegung des Kolbens (15) in der Kraftstoffabgaberichtung mit der unteren Neben-Leitnut (48; 54) in Verbindung tritt.
7. Kraftstoffeinspritzpumpe nach Anspruch 3, wobei der vertikale Kanal (55) gemeinsam von der unteren Haupt-Leitnut (53) und der unteren Neben-Leitnut (54) genutzt wird.
8. Kraftstoffeinspritzpumpe nach Anspruch 1, wobei eine obere Neben-Leitnut (57; 73) im oberen Endabschnitt (15A) des Kolbens (15) auf geneigte Weise ausgebildet ist, die bei Niedriglastbetrieb

Verbindung mit der Neben-Zuführöffnung (42) ermöglicht, und in der Richtung entgegengesetzt zu der unteren Haupt-Leitnut (44) und der unteren Neben-Leitnut (48) geneigt ist.

9. Kraftstoffeinspritzpumpe nach Anspruch 1, wobei eine obere Neben-Leitnut (61) im oberen Endabschnitt (15A) des Kolbens (15) auf geneigte Weise ausgebildet ist, die beim Hochlastbetrieb Verbindung mit der Neben-Zuführöffnung (42) ermöglicht, und in der gleichen Richtung geneigt ist wie die untere Haupt-Leitnut (44) und die untere Neben-Leitnut (48).

10. Kraftstoffeinspritzpumpe nach einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet**, daß der obere Endabschnitt (15A) des Kolbens (15) des weiteren eine obere Haupt-Leitnut (46; 77; 83) umfaßt, die über einen vorgeschriebenen Drehbereich des Kolbens (15) mit der Haupt-Zuführöffnung (41) in Verbindung treten kann, wobei die obere Neben-Leitnut (47; 73; 81) und die obere Haupt-Leitnut (46; 77; 83) so ausgebildet sind, daß die Neben-Zuführöffnung (42) in dem vorgeschriebenen Drehbereich des Kolbens (15) mit der oberen Neben-Leitnut (47; 73; 81) auch dann in Verbindung treten kann, wenn die Haupt-Zuführöffnung (41) durch die Oberkante (46A) der oberen Haupt-Leitnut (46; 77; 83) verschlossen wird, so daß die Haupt-Zuführöffnung (41), wenn sich der Kolben (15) in seiner Drehposition beim Anlaßvorgang befindet, durch den oberen Endabschnitt (15A) des Kolbens (15), der nicht mit der oberen Haupt-Leitnut (46; 77; 83) versehen ist, verschlossen werden kann, und die Neben-Zuführöffnung (42) durch den oberen Endabschnitt (15A) des Kolbens (15) verschlossen werden kann, der nicht mit der oberen Neben-Leitnut (47; 73; 81) versehen ist.

11. Kraftstoffeinspritzpumpe nach Anspruch 10, wobei eine obere Neben-Leitnut (73) im oberen Endabschnitt (15A) des Kolbens (15) auf geneigte Weise ausgebildet ist, die Verbindung mit der Neben-Zuführöffnung (42) bei Niedriglastbetrieb und bei Hochlastbetrieb ermöglicht, und in einer Richtung entgegengesetzt zu der unteren Haupt-Leitnut (44) und der unteren Neben-Leitnut (48) geneigt ist.

12. Kraftstoffeinspritzpumpe nach Anspruch 10, wobei eine obere Haupt-Leitnut (77) in dem oberen Endabschnitt (15A) des Kolbens (15) auf geneigte Weise ausgebildet ist, die bei Niedriglastbetrieb und bei Hochlastbetrieb Verbindung mit der Haupt-Zuführöffnung (41) ermöglicht, und die obere Haupt-Leitnut (77) in der gleichen Richtung geneigt ist wie die untere Haupt-Leitnut (44) und die untere Neben-Leitnut (48).

13. Kraftstoffeinspritzpumpe nach Anspruch 10, wobei eine obere Neben-Leitnut (81) im oberen Endabschnitt (15A) des Kolbens (15) auf geneigte Weise ausgebildet ist, die bei Niedriglastbetrieb und bei Hochlastbetrieb Verbindung mit der Neben-Zuführöffnung (42) ermöglicht, und in der gleichen Richtung geneigt ist wie die untere Haupt-Leitnut (44) und die untere Neben-Leitnut (48).

14. Kraftstoffeinspritzpumpe nach Anspruch 10, wobei eine obere Haupt-Leitnut (83) im oberen Endabschnitt (15A) des Kolbens (15) auf geneigte Weise ausgebildet ist, die bei Niedriglastbetrieb und bei Hochlastbetrieb Verbindung mit der Haupt-Zuführöffnung (41) ermöglicht, und in der Richtung entgegengesetzt zu der unteren Haupt-Leitnut (44) und der unteren Neben-Leitnut (48) geneigt ist.

15. Kombination aus einer Kraftstoffeinspritzpumpe und einer Einspritzdüse, wobei die Kombination umfaßt:

ein Pumpengehäuse (10), das mit einem Kraftstoffbehälter (20) versehen ist,

eine Kolbenhülse (14), die in dem Pumpengehäuse (10) angebracht ist und eine Haupt-Zuführöffnung (41) mit größeren Durchmesser sowie eine Neben-Zuführöffnung (42) mit kleineren Durchmesser aufweist, die mit dem Kraftstoffbehälter (20) in Verbindung stehen,

einen Kolben (15), der in der Kolbenhülse (14) aufgenommen ist und darin hin und her verschoben und gedreht werden kann und mit einer geneigten unteren Haupt-Leitnut (44; 98) versehen ist, die von einem oberen Endabschnitt (15A) des Kolbens (15) an einer Position zur Herstellung von Verbindung mit der Haupt-Zuführöffnung (41) beabstandet angeordnet ist, sowie eine Kraftstoffkammer (21), die zwischen dem Kolben (15) und der Kolbenhülse (14) ausgebildet ist, wobei bei Hin- und Herbewegung des Kolbens (15) Kraftstoff aus dem Kraftstoffbehälter (20) in die Kraftstoffkammer (21) angesaugt wird und des weiteren unter Druck einer Kraftstoffeinspritzdüse (6) zugeführt wird.

wobei der Kolben (15) über einen vorgeschriebenen Drehbereich seines Umfangs mit einer geneigten unteren Neben-Leitnut (48; 99) versehen ist, die vom oberen Endabschnitt (15A) des Kolbens (15) beabstandet angeordnet ist und mit der Neben-Zuführöffnung (42) in Verbindung treten kann, wobei die untere Neben-Leitnut (48; 99) unter dem oberen Endabschnitt (15A) des Kolbens (15) ausgebildet ist, **dadurch gekennzeichnet**, daß:

- die Kraftstoffeinspritzdüse (6) eine Drossel-Kraftstoffeinspritzdüse (6) ist, die in einen Zusatz-Brennraum (4, 9) eines Dieselmotors mit Verbrennungssystem mit unterteiltem Brennraum einspritzen kann, und
wobei an der Drehposition des Kolbens (15) bei Hochlastbetrieb die Haupt-Zuführöffnung (41) auch dann nicht mit der unteren Haupt-Leitnut (44; 98) in Verbindung steht, wenn die Neben-Zuführöffnung (42) mit der unteren Neben-Leitnut (48; 99) aufgrund der Bewegung des Kolbens (15) in der Kraftstoffabgaberrichtung in Verbindung tritt, und die Neigung der unteren Haupt-Leitnut (44; 98) größer ist als die der unteren Neben-Leitnut (48; 99), und
wobei an der Drehposition des Kolbens (15) bei Niedriglastbetrieb die Neben-Zuführöffnung (42) auch dann nicht mit der unteren Neben-Leitnut (48; 99) in Verbindung steht, wenn die Haupt-Zuführöffnung (41) mit der unteren Haupt-Leitnut (44; 98) aufgrund der Bewegung des Kolbens (15) in der Kraftstoffabgaberrichtung in Verbindung tritt.
16. Kombination aus einer Kraftstoffeinspritzpumpe und einer Einspritzdüse nach Anspruch 15, wobei die Kraftstoffeinspritzdüse (6) umfaßt:
- einen Düsenkörper (26), der an seiner Spitze mit einem Düsenloch (37) versehen ist, das einen zylindrischen Wandabschnitt (37A) und einen Sitzabschnitt (37B) aufweist, und
- ein Nadelventil (30), das in dem Düsenkörper (26) verschoben werden kann, um das Düsenloch (37) zu öffnen und zu schließen, und dessen Spitzenabschnitt durch ein Zapfenelement (30A) und einen konischen Abschnitt (30B) gebildet wird,
- wobei das Zapfenelement (30A) dem zylindrischen Wandabschnitt (37A) gegenüber angeordnet ist und der konische Abschnitt (30B) dem Sitzabschnitt (37B) gegenüber angeordnet ist.
17. Kombination aus einer Kraftstoffeinspritzpumpe und einer Einspritzdüse nach Anspruch 15, wobei eine Oberkante (42A) der Neben-Zuführöffnung (42) nicht höher liegt als eine Oberkante (41A) der Haupt-Zuführöffnung (41).
18. Kombination aus einer Kraftstoffeinspritzpumpe und einer Einspritzdüse nach Anspruch 15, wobei der Kolben (15) mit einem vertikalen Kanal (43, 45; 97) versehen ist, der mit der Kraftstoffkammer (21), der unteren Haupt-Leitnut (44; 98) und der unteren Neben-Leitnut (48; 99) in Verbindung treten kann.

19. Kombination aus einer Kraftstoffeinspritzpumpe und einer Einspritzdüse nach Anspruch 18, wobei der vertikale Kanal (97) gemeinsam von der unteren Haupt-Leitnut (98) und der unteren Neben-Leitnut (99) genutzt wird.
20. Kombination aus einer Kraftstoffeinspritzpumpe und einer Einspritzdüse nach Anspruch 15, wobei die untere Haupt-Leitnut (44; 98) und die untere Neben-Leitnut (48; 99) so ausgebildet sind, daß sie in der Richtung von der Niedriglastseite zur Hochlastseite und in der Abwärtsrichtung des Kolbens (15) geneigt sind.
21. Kombination aus einer Kraftstoffeinspritzpumpe und einer Einspritzdüse nach Anspruch 15, wobei das obere Ende (15A) des Kolbens (15) mit einer oberen Haupt-Leitnut (95) versehen ist, die bei Hochlastbetrieb mit der Haupt-Zuführöffnung (41) in Verbindung stehen kann und in der gleichen Richtung geneigt ist wie die untere Haupt-Leitnut (44) und die Neben-Leitnut (48).

Revendications

1. Pompe d'injection de carburant, comprenant :

un logement de pompe (10) configuré avec un réservoir de carburant (20),
un boisseau de plongeur (14) monté dans le logement de pompe (10) et présentant un orifice principal d'alimentation (41) de grand diamètre et un orifice secondaire d'alimentation (42) de petit diamètre qui communiquent avec le réservoir de carburant (20), le bord supérieur (42A) de l'orifice secondaire d'alimentation (42) étant situé en dessous du bord supérieur (41A) de l'orifice principal d'alimentation (41) ou à la même hauteur,
un plongeur (15) logé dans le boisseau de plongeur (14), capable de s'y déplacer de manière coulissante en va-et-vient et en rotation dans celui-ci et configuré avec une rainure principale inférieure de guidage (44 ; 53) oblique située à distance d'une partie d'extrémité supérieure (15A) du plongeur (15) en une position permettant la communication avec l'orifice principal d'alimentation (41), et une chambre à carburant (21) formée entre le plongeur (15) et le boisseau de plongeur (14), de telle sorte que lorsque le plongeur (15) se déplace en va-et-vient, du carburant est aspiré dans la chambre à carburant (21) depuis le réservoir de carburant (20) et est ensuite délivré sous pression à un gicleur d'injection de carburant (6),
la partie de tête du plongeur (15) étant configurée avec une rainure supérieure de guidage secondaire (47 ; 57 ; 61 ; 73 ; 81) apte à com-

muniquer avec l'orifice secondaire d'alimentation (42) sur une plage prescrite de rotation du plongeur (15) et à maintenir la communication avec l'orifice secondaire d'alimentation (42) même lorsque l'orifice principal d'alimentation (41) est fermé par la partie d'extrémité supérieure (15A) du plongeur (15),

le plongeur (15) est doté sur une plage prescrite de rotation de sa circonférence d'une rainure inférieure oblique de guidage secondaire (48 ; 54) disposée à distance de la partie d'extrémité supérieure (15A) du plongeur (15) et apte à communiquer avec l'orifice secondaire d'alimentation (42), ladite rainure inférieure de guidage secondaire (48 ; 54) étant aussi formée en dessous de la partie d'extrémité supérieure (15A) du plongeur,

la rainure inférieure de guidage principale (44 ; 53) et la rainure inférieure de guidage secondaire (48 ; 54) étant configurées de manière à former une pente dans la direction allant du côté à faible charge au côté à forte charge et dans la direction allant vers le bas du plongeur (15),

caractérisé en ce que dans la position de rotation du plongeur (15) pendant le fonctionnement à forte charge, l'orifice principal d'alimentation (41) ne communique pas avec la rainure inférieure de guidage principale (44 ; 53) même lorsque l'orifice secondaire d'alimentation (42) entre en communication avec la rainure inférieure de guidage secondaire (48 ; 54) du fait du déplacement du plongeur (15) dans la direction de fourniture de carburant, et la pente de la rainure inférieure de guidage principale (44 ; 53) est plus forte que celle de la rainure inférieure de guidage secondaire (48 ; 54).

2. Pompe d'injection de carburant selon la revendication 1, dans laquelle, dans la position de rotation du plongeur (15) pendant le fonctionnement à faible charge, l'orifice secondaire d'alimentation (42) ne communique pas avec la rainure inférieure de guidage secondaire (48 ; 54) même lorsque l'orifice principal d'alimentation (41) entre en communication avec la rainure inférieure de guidage principale (44 ; 53) du fait du déplacement du plongeur (15) dans la direction de fourniture de carburant.

3. Pompe d'injection de carburant selon la revendication 1, dans laquelle le plongeur (15) est configuré avec un passage vertical (43, 45 ; 55) apte à communiquer avec la chambre à carburant (21), la rainure inférieure de guidage principale (44 ; 53) et la rainure inférieure de guidage secondaire (48 ; 54).

4. Pompe d'injection de carburant selon la revendica-

tion 1, dans laquelle les positions auxquelles l'orifice principal d'alimentation (41) et l'orifice secondaire d'alimentation (42) sont situés face à la rainure inférieure de guidage principale (44 ; 53) et à la rainure inférieure de guidage secondaire (48 ; 54) descendent progressivement sur le plongeur (15) dans une direction en pente vers le bas, dans l'ordre des positions correspondant à un fonctionnement à faible charge, un fonctionnement à forte charge et le démarrage.

5. Pompe d'injection de carburant selon la revendication 1, dans laquelle, au démarrage, l'orifice secondaire d'alimentation (42) est disposé en face de la partie d'extrémité supérieure (15A) du plongeur (15) non configurée avec la rainure supérieure de guidage secondaire (47 ; 57 ; 61 ; 73 ; 81).

6. Pompe d'injection de carburant selon la revendication 1, dans laquelle, dans la position de rotation du plongeur (15) pendant le fonctionnement à forte charge et dans celle du fonctionnement à faible charge, l'orifice principal d'alimentation (41) ne communique pas avec la rainure inférieure de guidage principale (44 ; 53) même lorsque l'orifice secondaire d'alimentation (42) entre en communication avec la rainure inférieure de guidage secondaire (48 ; 54) du fait du déplacement du plongeur (15) dans la direction de fourniture de carburant.

7. Pompe d'injection de carburant selon la revendication 3, dans laquelle le passage vertical (55) est utilisé en commun par la rainure inférieure de guidage principale (53) et la rainure inférieure de guidage secondaire (54).

8. Pompe d'injection de carburant selon la revendication 1, dans laquelle une rainure supérieure de guidage secondaire (57 ; 73) est formée dans la partie d'extrémité supérieure (15A) du plongeur (15), d'une manière inclinée permettant la communication avec l'orifice secondaire d'alimentation (42) pendant le fonctionnement à faible charge, et en pente dans la direction opposée à celle de la rainure inférieure de guidage principale (44) et la rainure inférieure de guidage secondaire (48).

9. Pompe d'injection de carburant selon la revendication 1, dans laquelle une rainure supérieure de guidage secondaire (61) est formée dans la partie d'extrémité supérieure (15A) du plongeur (15), d'une manière inclinée permettant la communication avec l'orifice secondaire d'alimentation (42) pendant le fonctionnement à haute charge, et en pente dans la même direction à celle de la rainure inférieure de guidage principale (44) et la rainure inférieure de guidage secondaire (48).

10. Pompe d'injection de carburant selon l'une des revendications 1 à 9, caractérisée en ce que la partie d'extrémité supérieure (15A) du plongeur (15) comprend en outre une rainure supérieure de guidage principale (46 ; 77 ; 83) apte à communiquer avec l'orifice principal d'alimentation (41) sur une plage prescrite de rotation du plongeur (15), la rainure supérieure de guidage secondaire (47 ; 73 ; 81) et la rainure supérieure de guidage principale (46 ; 77 ; 83) étant configurées de telle sorte que dans la plage prescrite de rotation du plongeur (15), l'orifice secondaire d'alimentation (42) est capable de maintenir la communication avec la rainure supérieure de guidage secondaire (47 ; 73 ; 81) même lorsque l'orifice principal d'alimentation (41) est fermé par le bord supérieur (46A) de la rainure supérieure de guidage principale (46 ; 77 ; 83), de telle sorte que lorsque le plongeur (15) est dans sa position de rotation pendant le fonctionnement de démarrage, l'orifice principal d'alimentation (41) peut être fermé par la partie d'extrémité supérieure (15A) du plongeur (15) qui n'est pas configurée avec la rainure supérieure de guidage principale (46 ; 77 ; 83) et que l'orifice secondaire d'alimentation (42) peut être fermé par la partie d'extrémité supérieure (15A) du plongeur (15) qui n'est pas configurée avec la rainure supérieure de guidage secondaire (47 ; 73 ; 81).
11. Pompe d'injection de carburant selon la revendication 10, dans laquelle une rainure supérieure de guidage secondaire (73) est formée dans la partie d'extrémité supérieure (15A) du plongeur (15), d'une manière inclinée apte à communiquer avec l'orifice secondaire d'alimentation (42) pendant le fonctionnement à faible charge et le fonctionnement à forte charge, et dont la pente s'étend dans la direction opposée à celle de la rainure inférieure de guidage principale (44) et de la rainure inférieure de guidage secondaire (48).
12. Pompe d'injection de carburant selon la revendication 10, dans laquelle une rainure supérieure de guidage principale (77) est formée dans la partie d'extrémité supérieure (15A) du plongeur (15), d'une manière inclinée apte à communiquer avec l'orifice principal d'alimentation (41) pendant le fonctionnement à faible charge et le fonctionnement à forte charge, la rainure supérieure de guidage principale (77) présentant une pente qui s'étend dans la même direction que celle de la rainure inférieure de guidage principale (44) et de la rainure inférieure de guidage secondaire (48).
13. Pompe d'injection de carburant selon la revendication 10, dans laquelle une rainure supérieure de guidage secondaire (81) est formée dans la partie d'extrémité supérieure (15A) du plongeur (15), d'une manière inclinée apte à communiquer avec l'orifice secondaire d'alimentation (42) pendant le fonctionnement à faible charge et le fonctionnement à forte charge, et dont la pente s'étend dans la même direction que la rainure inférieure de guidage principale (44) et la rainure inférieure de guidage secondaire (48).
14. Pompe d'injection de carburant selon la revendication 10, dans laquelle une rainure supérieure de guidage principale (83) est formée dans la partie d'extrémité supérieure (15A) du plongeur (15), d'une manière inclinée apte à communiquer avec l'orifice principal d'alimentation (41) pendant le fonctionnement à faible charge et le fonctionnement à forte charge, et dont la pente s'étend dans la direction opposée à celle de la rainure inférieure de guidage principale (44) et de la rainure inférieure de guidage secondaire (48).
15. Combinaison d'une pompe d'injection de carburant et d'un gicleur d'injection, ladite combinaison comprenant :
- un logement de pompe (10) configuré avec un réservoir de carburant (20),
 - un boisseau de plongeur (14) monté dans le logement de pompe (10) et présentant un orifice principal d'alimentation (41) de grand diamètre et un orifice secondaire d'alimentation (42) de petit diamètre qui communiquent avec le réservoir de carburant (20),
 - un plongeur (15) logé dans le boisseau de plongeur (14), capable de s'y déplacer de manière coulissante en va-et-vient et en rotation dans celui-ci et configuré avec une rainure principale inférieure de guidage (44 ; 98) oblique située à distance d'une partie d'extrémité supérieure (15A) du plongeur (15) en une position permettant la communication avec l'orifice principal d'alimentation (41), et une chambre à carburant (21) formée entre le plongeur (15) et le boisseau de plongeur (14), de telle sorte que lorsque le plongeur (15) se déplace en va-et-vient, du carburant est aspiré dans la chambre à carburant (21) depuis le réservoir de carburant (20) et est ensuite délivré sous pression à un gicleur d'injection de carburant (6),
 - le plongeur (15) étant doté sur une plage prescrite de rotation de sa circonférence d'une rainure inférieure oblique de guidage secondaire (48 ; 99) disposée à distance de la partie d'extrémité supérieure (15A) du plongeur (15) et apte à communiquer avec l'orifice secondaire d'alimentation (42), ladite rainure inférieure de guidage secondaire (48 ; 99) étant formée en dessous de la partie d'extrémité supérieure (15) du plongeur,

caractérisée en ce que

le gicleur (6) d'injection de carburant est un gicleur (6) d'injection de carburant à étranglement, adapté pour l'injection dans une chambre de combustion auxiliaire (4, 9) d'un moteur diesel à système de combustion en chambre divisée, et

lorsque le plongeur (15) est dans sa position de rotation qui correspond au fonctionnement à forte charge, l'orifice principal d'alimentation (41) ne communique pas avec la rainure inférieure de guidage principale (44 ; 98) même lorsque l'orifice secondaire d'alimentation (42) entre en communication avec la rainure inférieure de guidage secondaire (48 ; 99) du fait du déplacement du plongeur (15) dans la direction de fourniture de carburant, et la pente de la rainure inférieure de guidage principale (44 ; 98) est plus forte que celle de la rainure inférieure de guidage secondaire (48 ; 99), et lorsque le plongeur (15) est dans sa position de rotation qui correspond au fonctionnement à faible charge, l'orifice secondaire d'alimentation (42) ne communique pas avec la rainure inférieure de guidage secondaire (48 ; 99) même lorsque l'orifice principal d'alimentation (41) entre en communication avec la rainure inférieure de guidage principale (44 ; 98) du fait du déplacement du plongeur (15) dans la direction de fourniture de carburant.

16. Combinaison d'une pompe d'injection de carburant et d'un gicleur d'injection selon la revendication 15, dans laquelle le gicleur (6) d'injection de carburant comprend :

un corps de gicleur (26) configuré à sa pointe avec un trou de gicleur (37) doté d'une partie de paroi cylindrique (37A) et d'une partie de siège (37B), et

une soupape à pointeau (30) pouvant coulisser à l'intérieur du corps de gicleur (26) pour ouvrir et fermer le trou de gicleur (37) et dont la partie de pointe est constituée d'un organe en pointeau (30A) et d'une partie conique (30B), ledit organe en pointeau (30A) étant disposé en face de ladite partie de paroi cylindrique (37A), et ladite partie conique (30B) étant disposée en face de la partie de siège (37B).

17. Combinaison d'une pompe d'injection de carburant et d'un gicleur d'injection selon la revendication 15, dans laquelle un bord supérieur (42A) de l'orifice secondaire d'alimentation (42) n'est pas situé plus haut qu'un bord supérieur (41A) de l'orifice principal d'alimentation (41).

18. Combinaison d'une pompe d'injection de carburant

et d'un gicleur d'injection selon la revendication 15, dans laquelle le plongeur (15) est configuré avec un passage vertical (43, 45 ; 97) apte à communiquer avec la chambre à carburant (21), la rainure inférieure de guidage principale (44 ; 98) et la rainure inférieure de guidage secondaire (48 ; 99).

19. Combinaison d'une pompe d'injection de carburant et d'un gicleur d'injection selon la revendication 18, dans laquelle le passage vertical (97) est utilisé en commun par la rainure inférieure de guidage principale (98) et la rainure inférieure de guidage secondaire (99).

20. Combinaison d'une pompe d'injection de carburant et d'un gicleur d'injection selon la revendication 15, dans laquelle la rainure inférieure de guidage principale (44 ; 98) et la rainure inférieure de guidage secondaire (48 ; 99) sont configurées de manière à être en pente dans la direction allant du côté à faible charge au côté à forte charge et dans la direction allant vers le bas du plongeur (15).

21. Combinaison d'une pompe d'injection de carburant et d'un gicleur d'injection selon la revendication 15, dans laquelle la partie d'extrémité supérieure (15A) du plongeur (15) est configurée avec une rainure supérieure de guidage principale (95) apte, à communiquer avec l'orifice principal d'alimentation (41) pendant le fonctionnement à forte charge et présentant une pente qui s'étend dans la même direction que celle de la rainure inférieure de guidage principale (44) et de la rainure inférieure de guidage secondaire (48).

FIG. 1

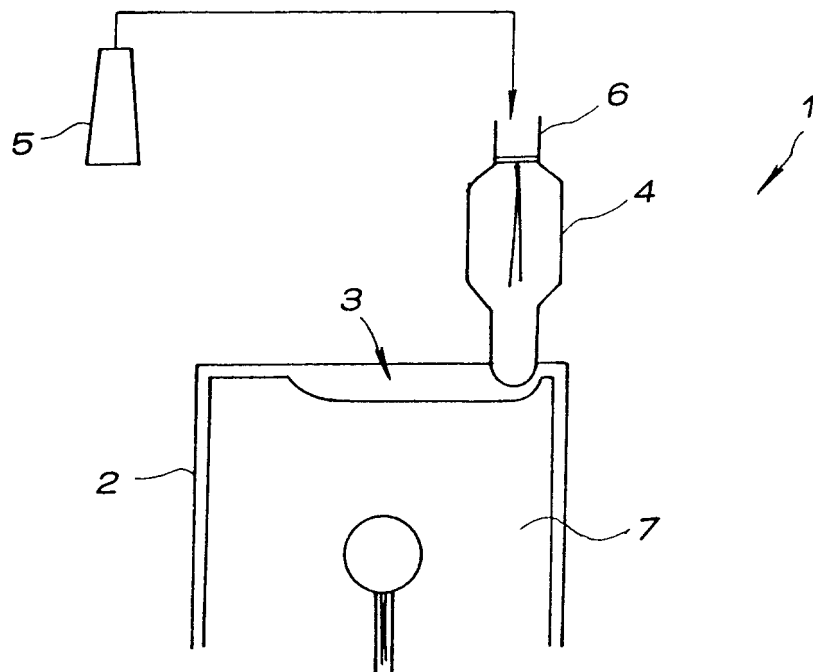


FIG. 2

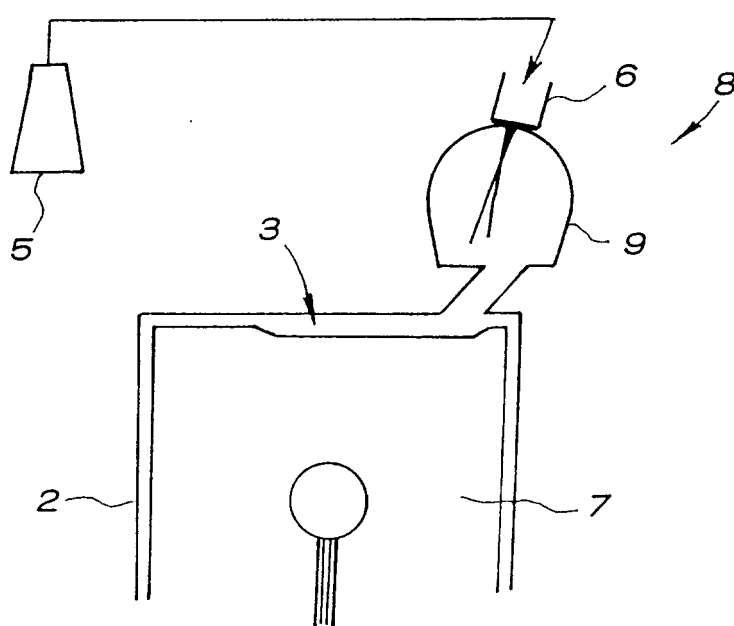


FIG. 3

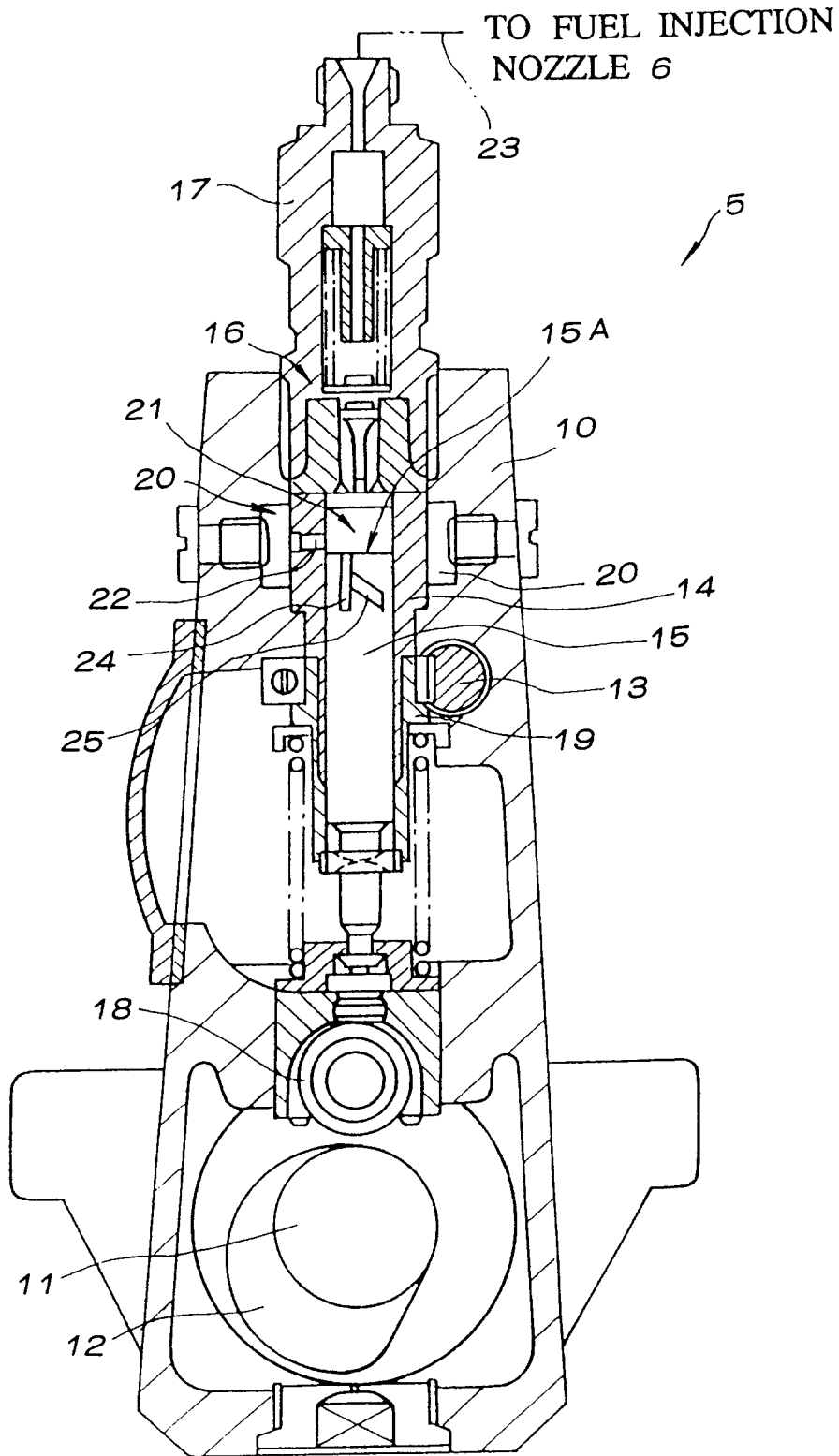


FIG. 4

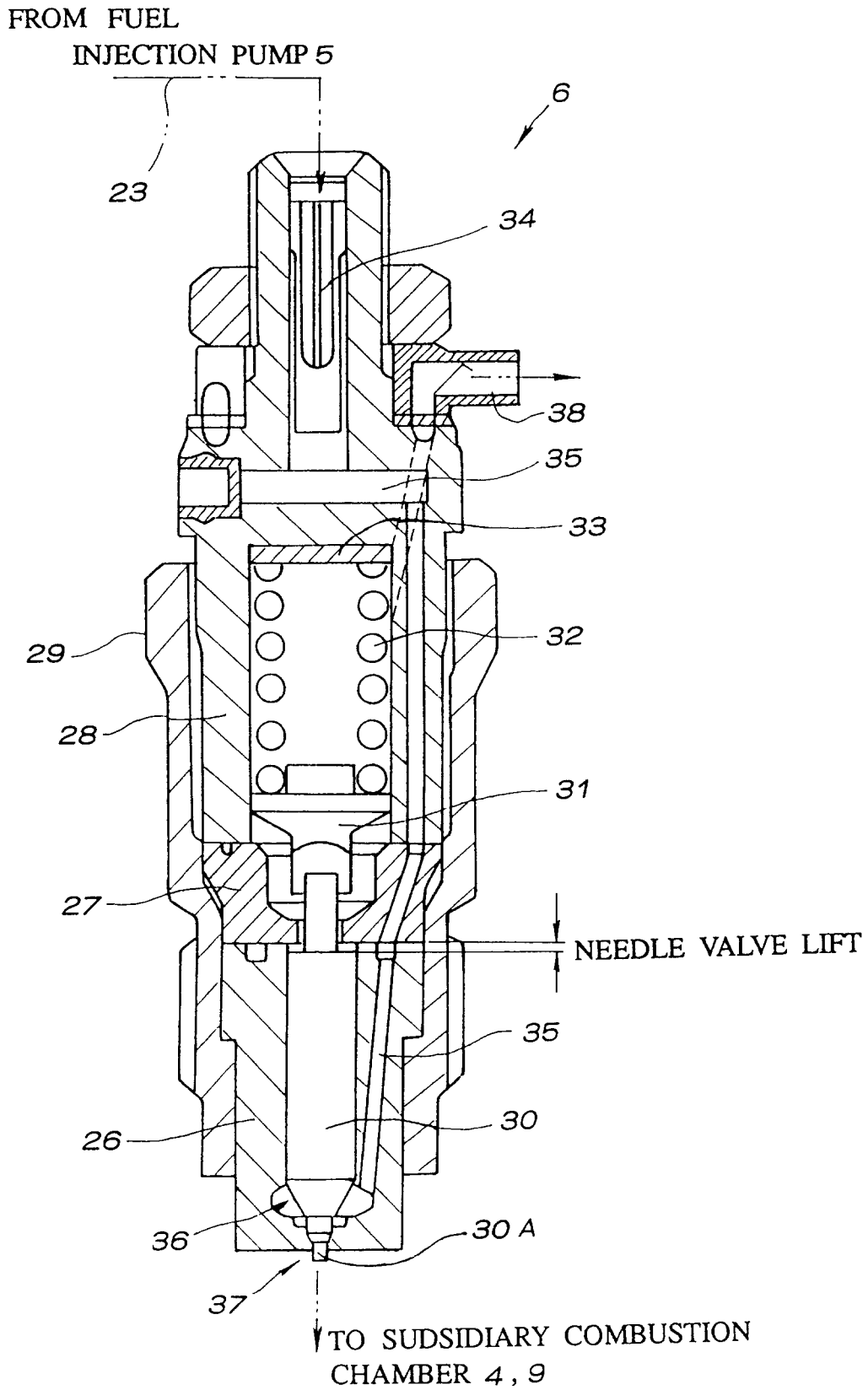


FIG. 5

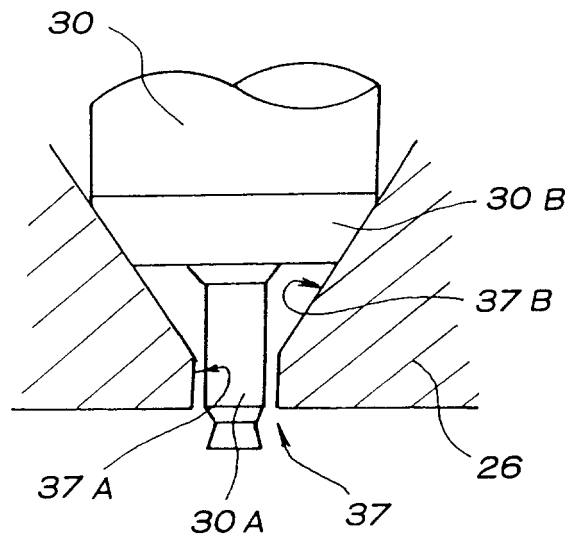


FIG. 6

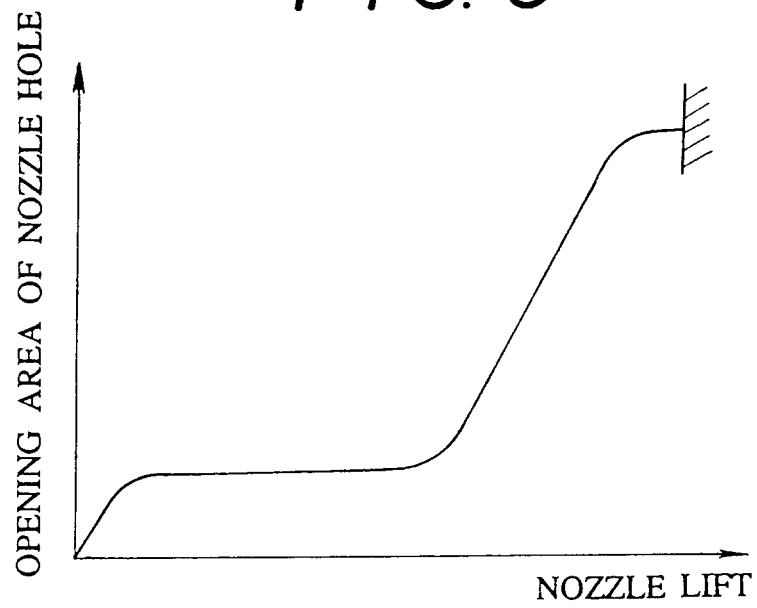


FIG. 7

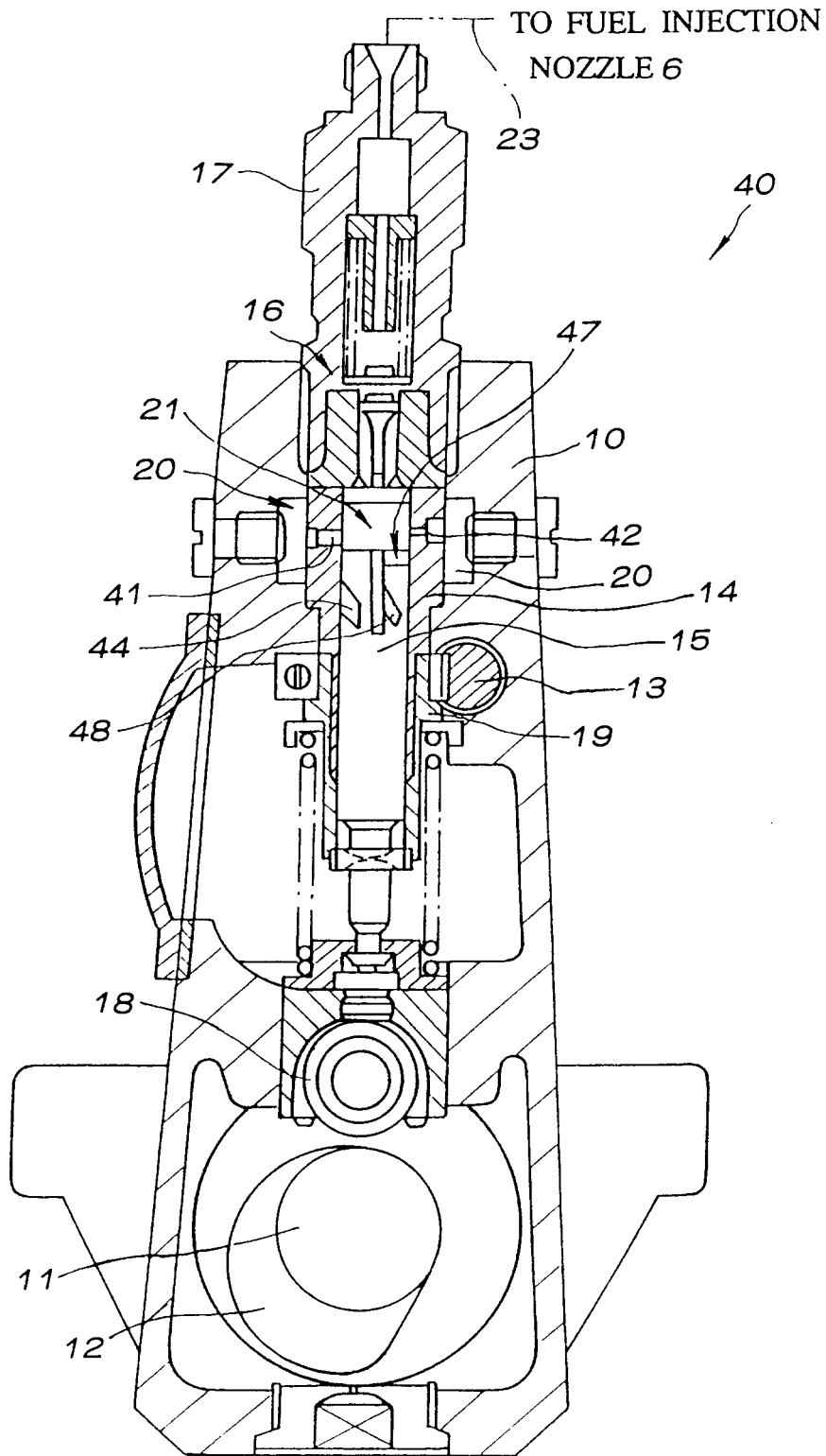


FIG. 8

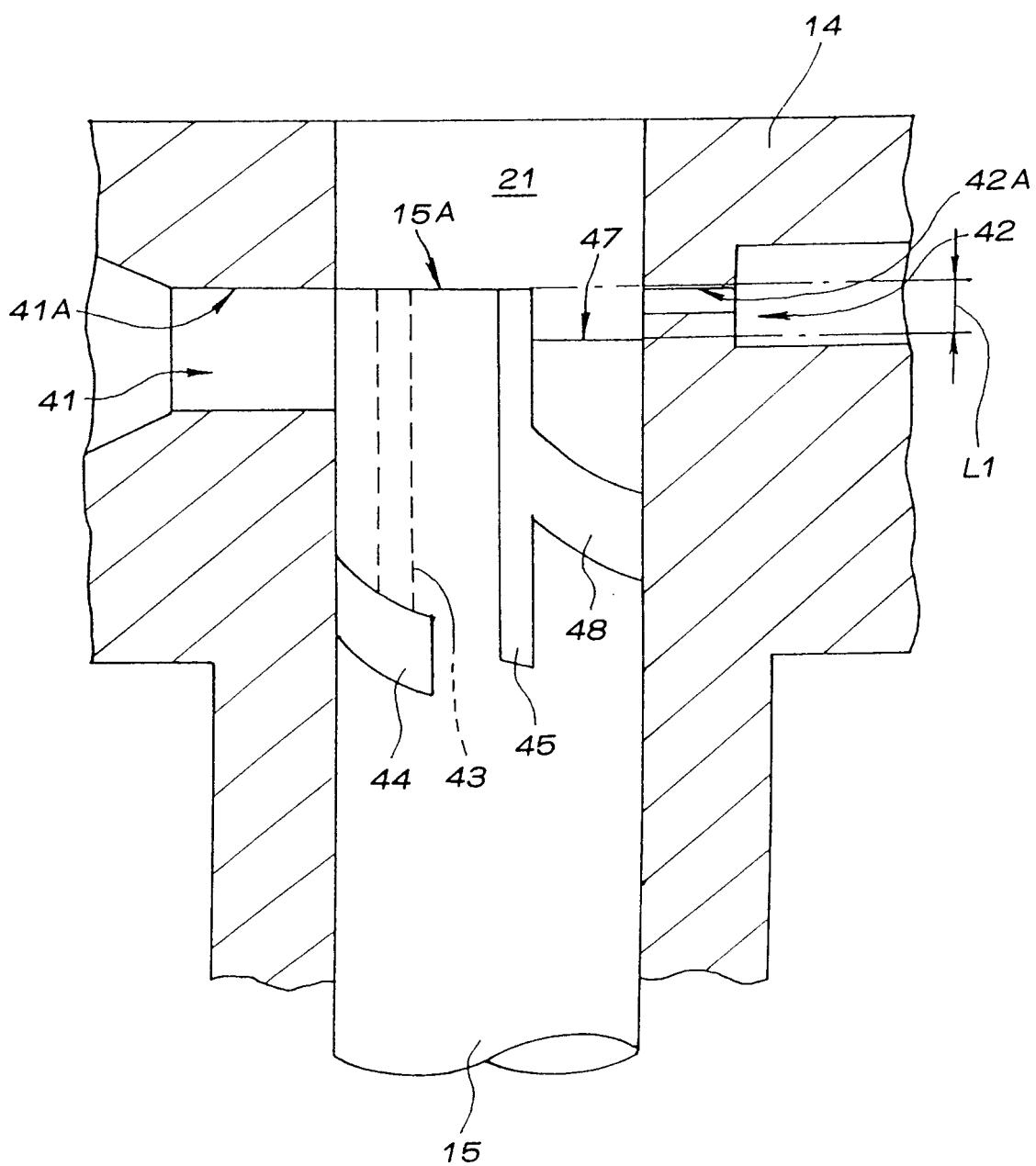


FIG. 9

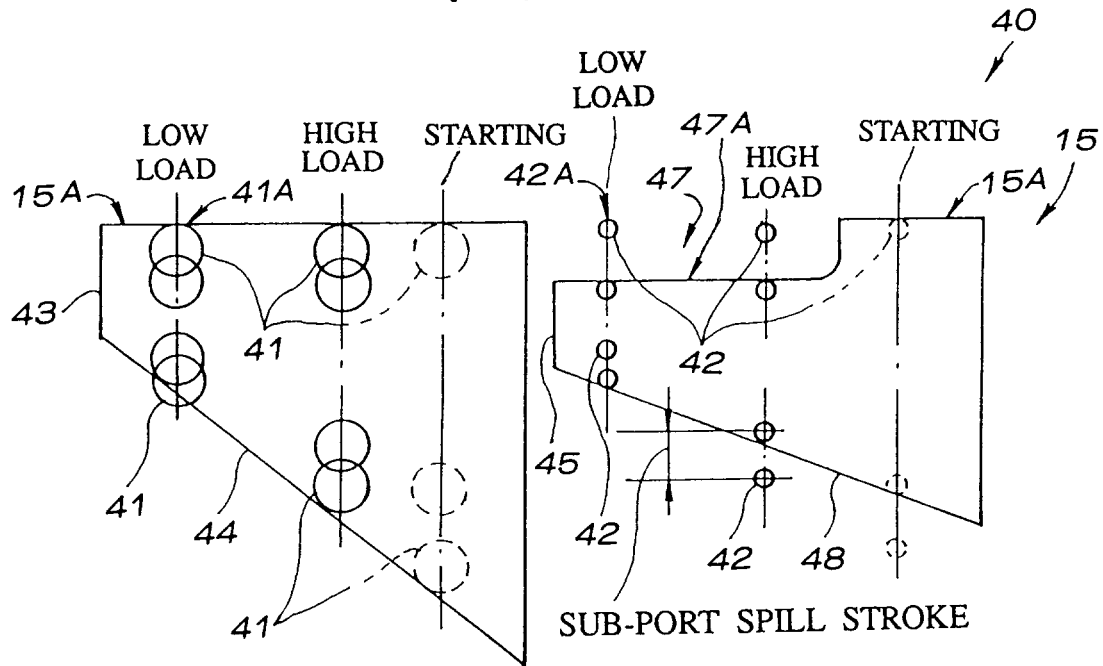


FIG. 10

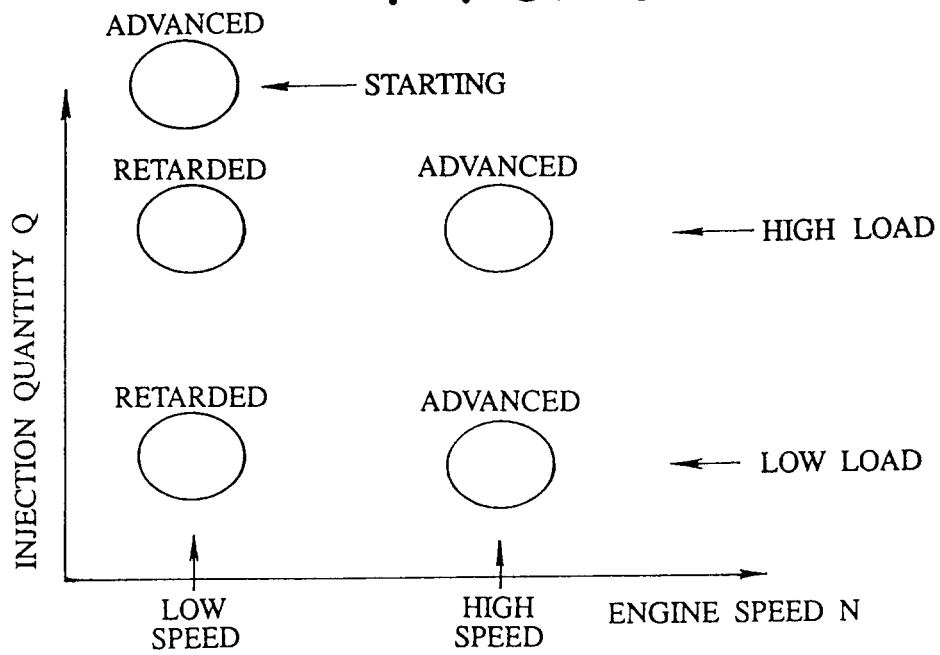


FIG. 11

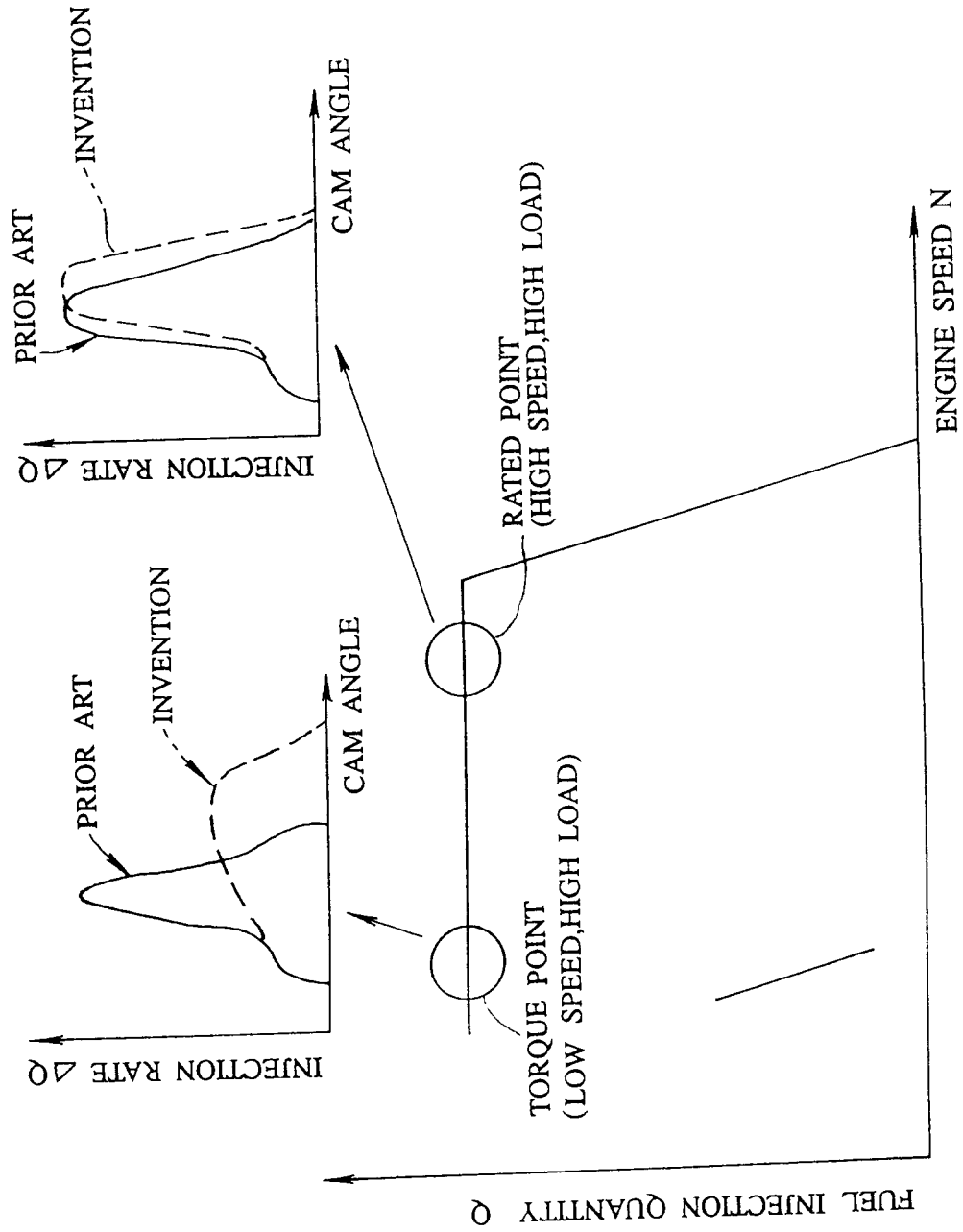


FIG. 12

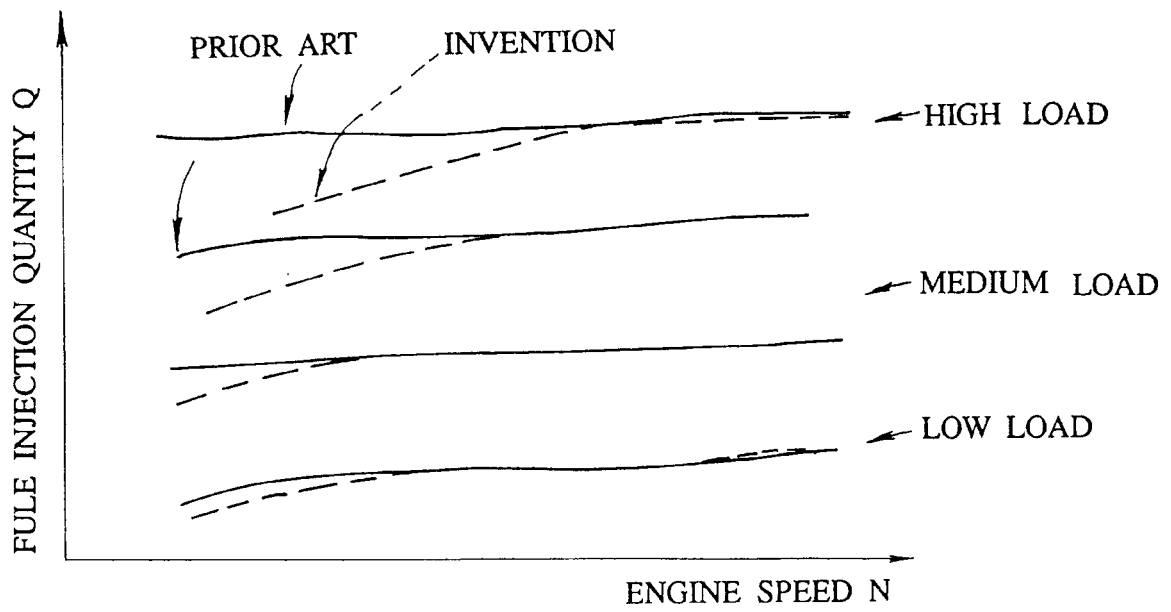


FIG. 13

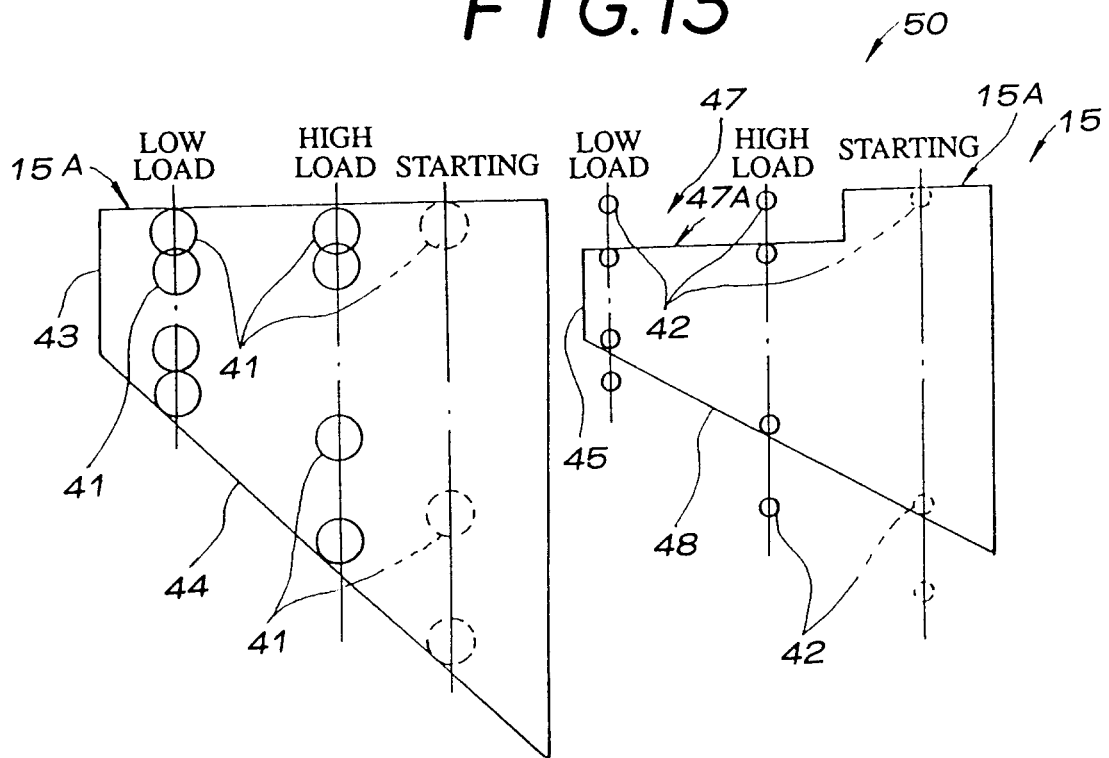


FIG. 14

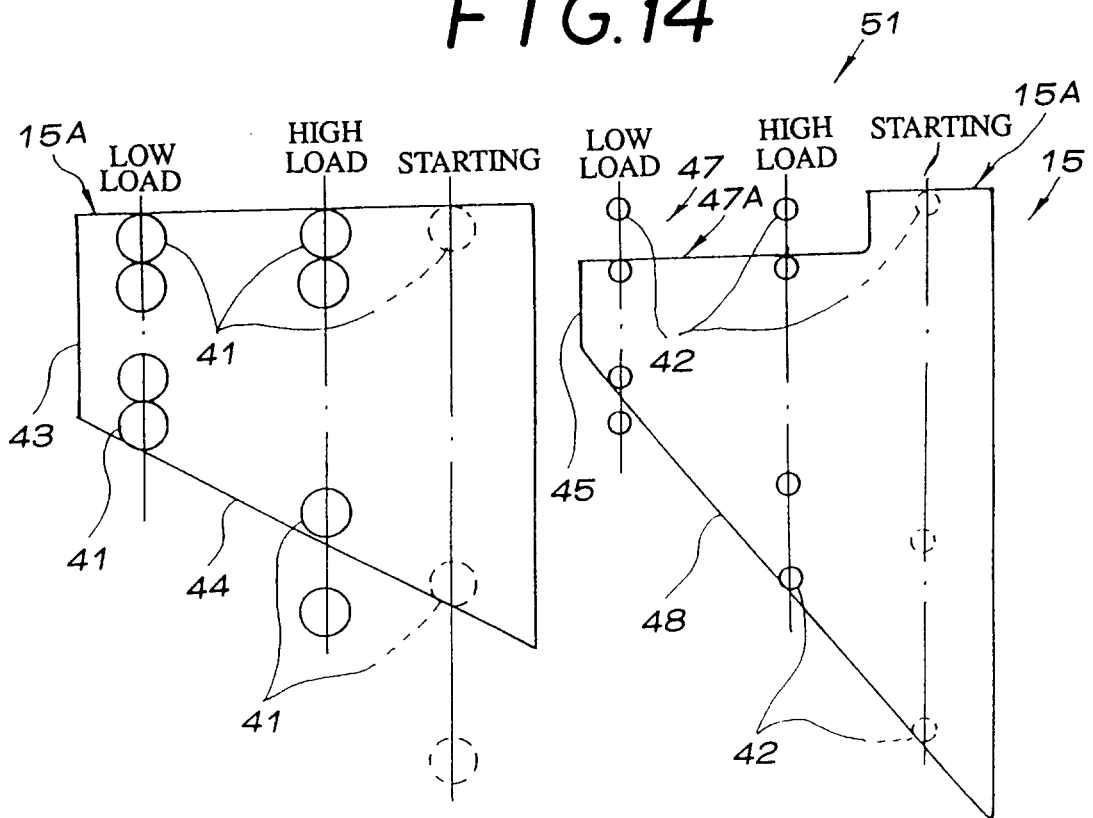


FIG. 15

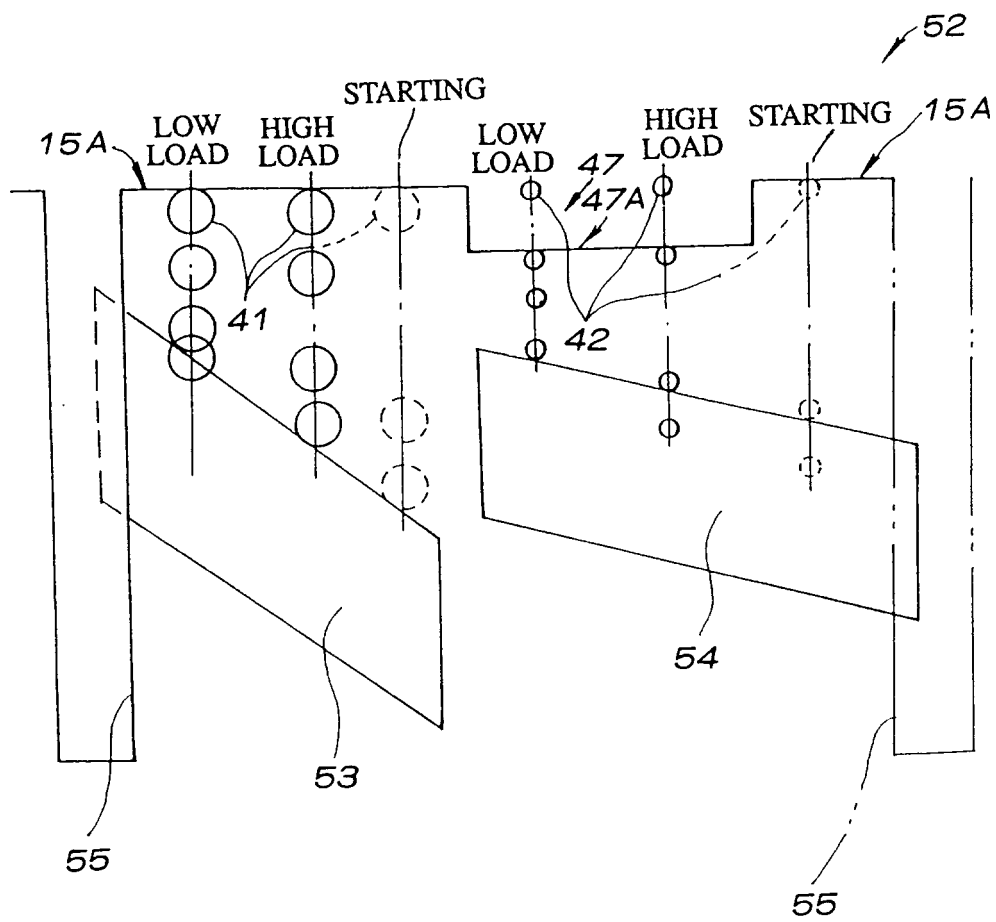


FIG.16

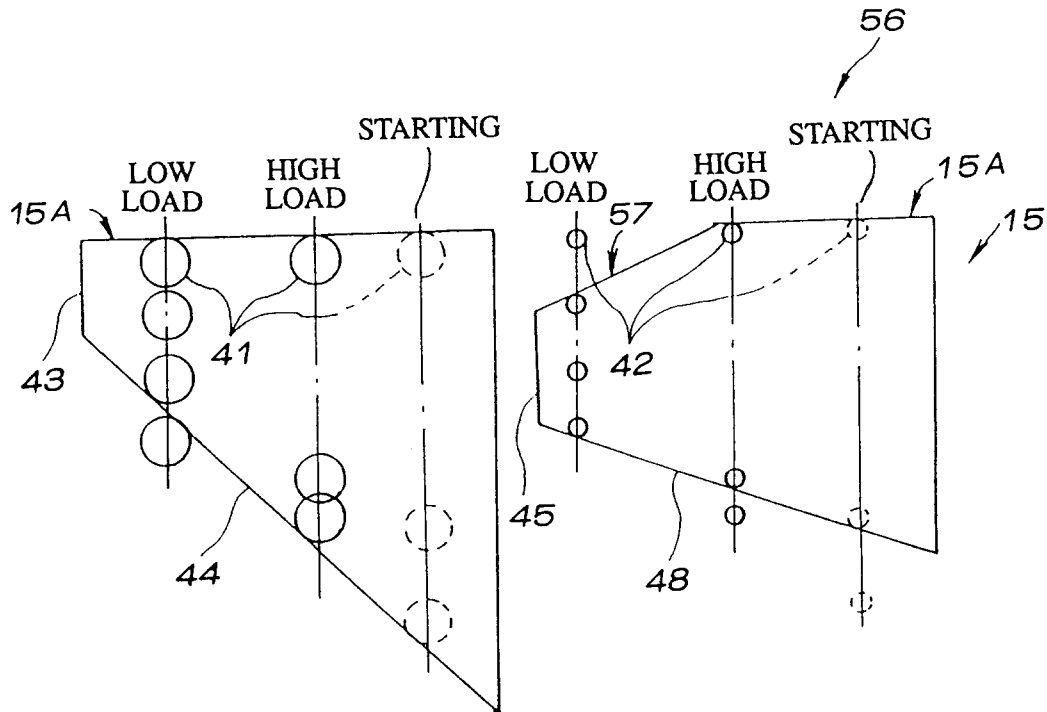


FIG.17

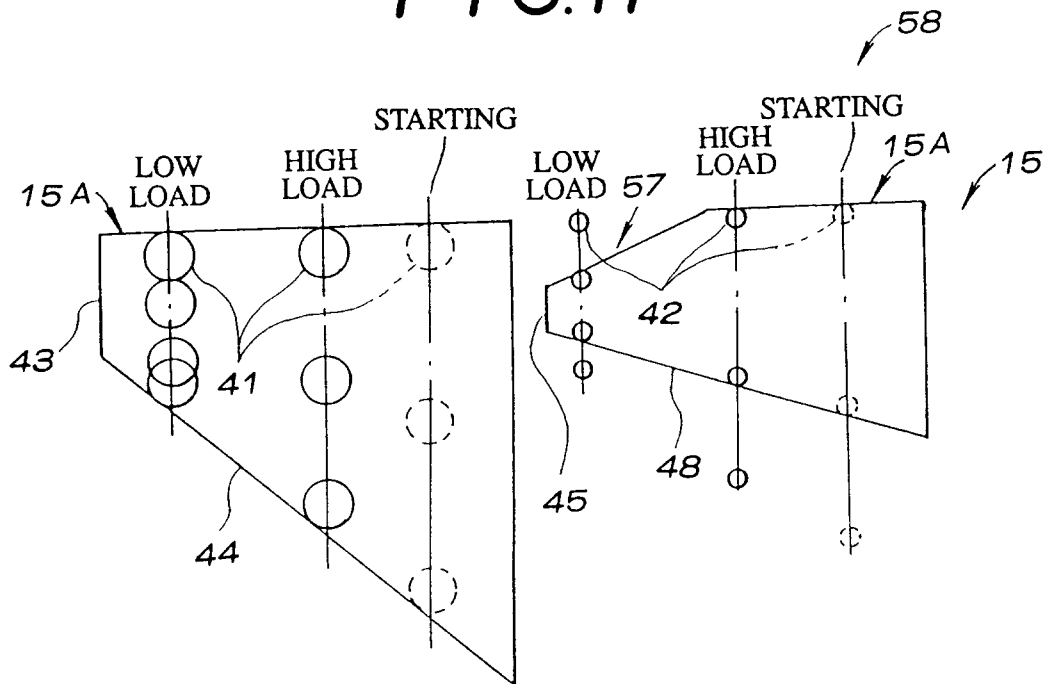


FIG. 18

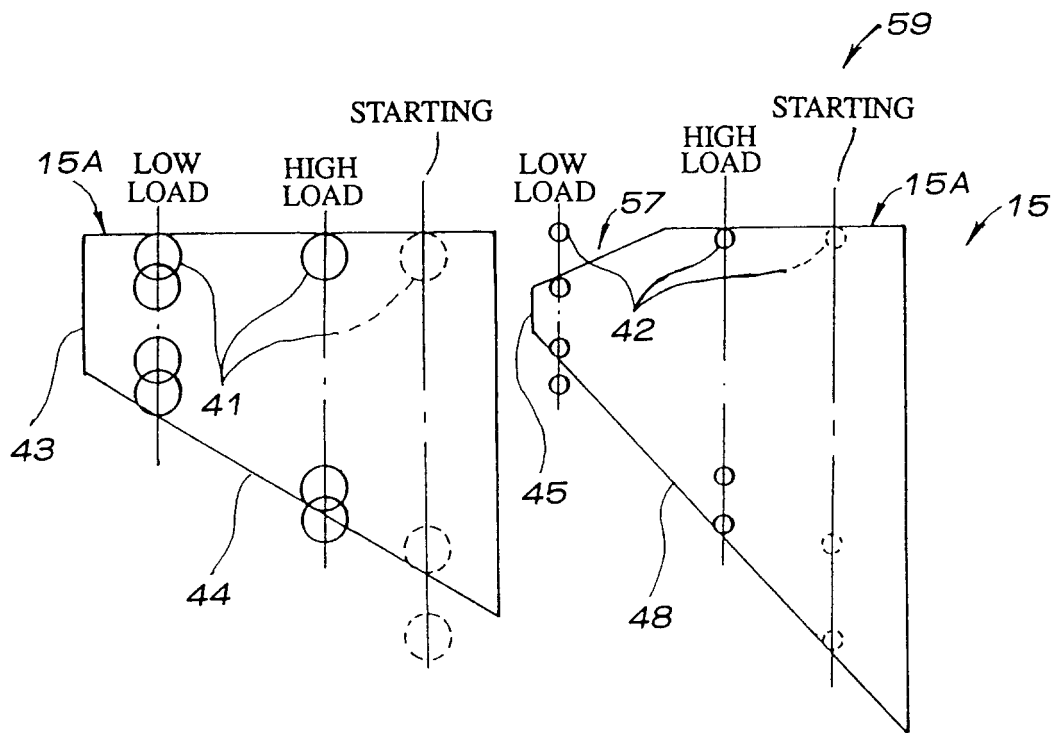


FIG.19

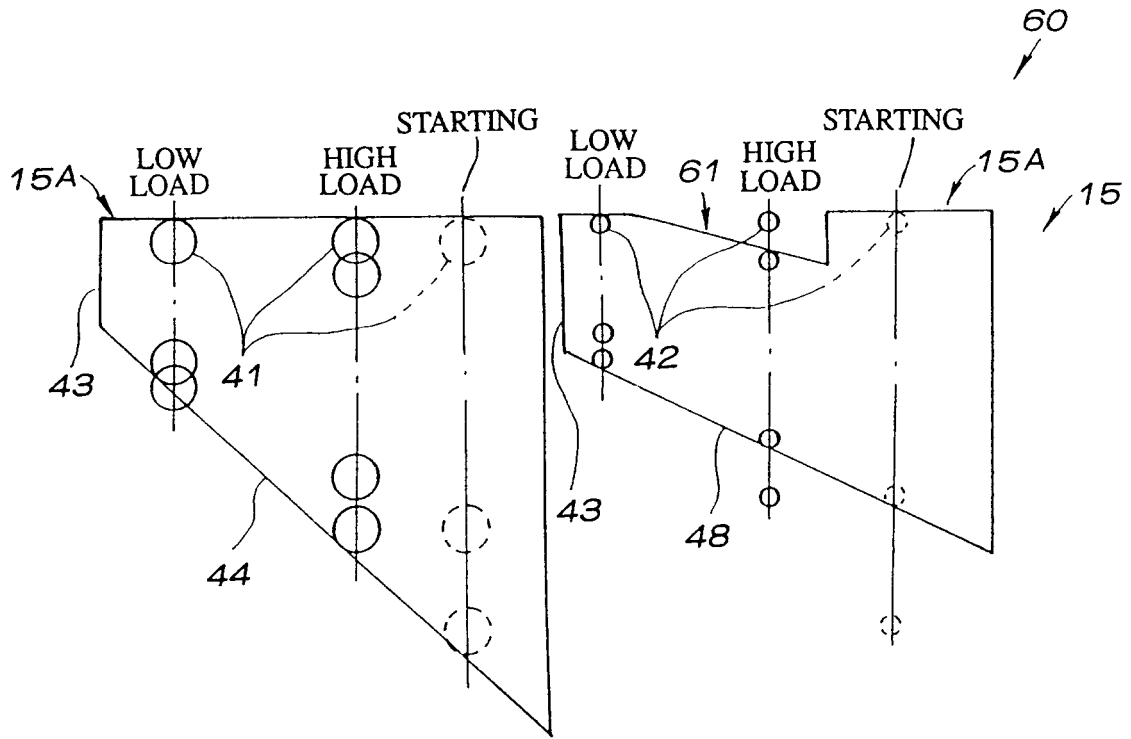


FIG.20

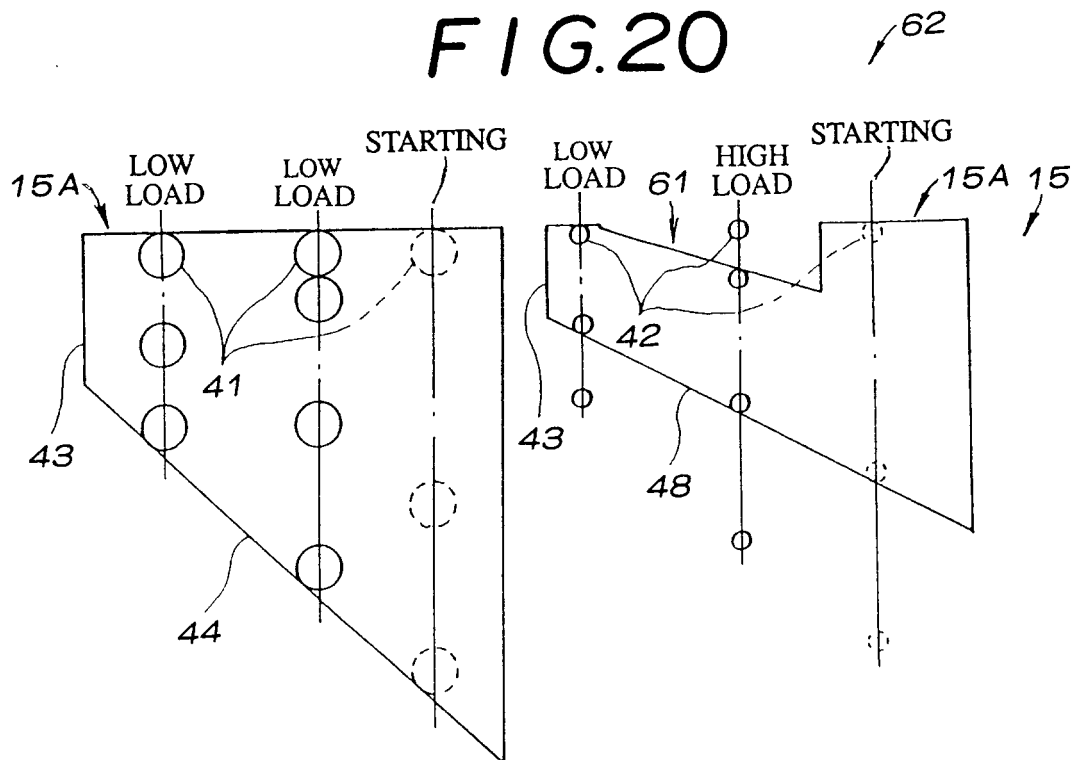


FIG. 21

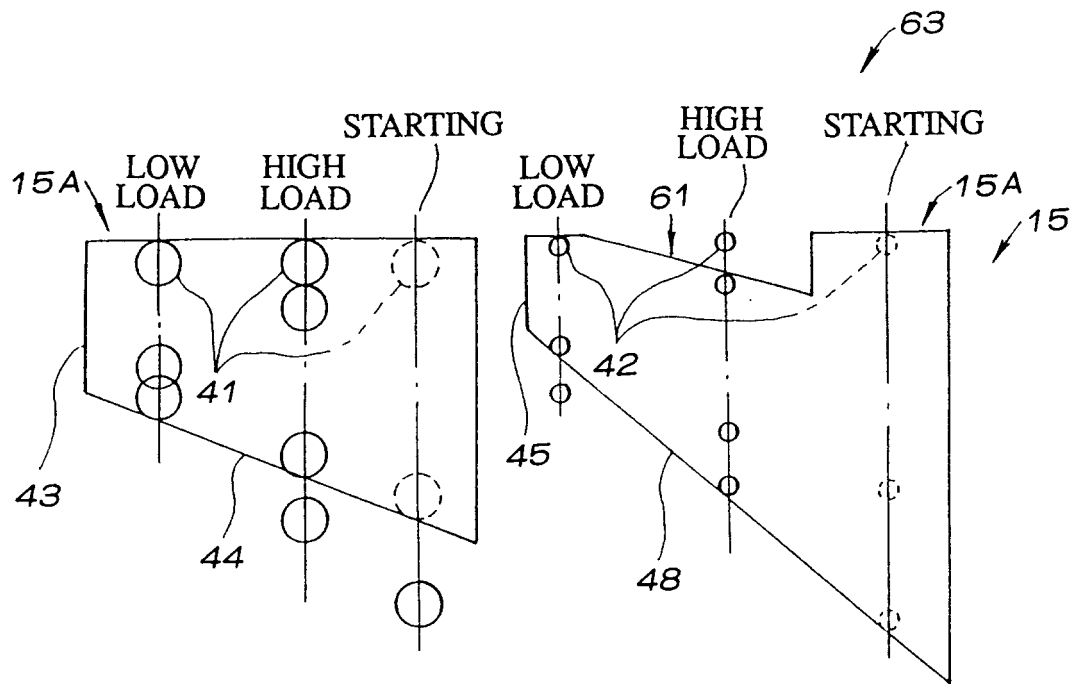


FIG. 22

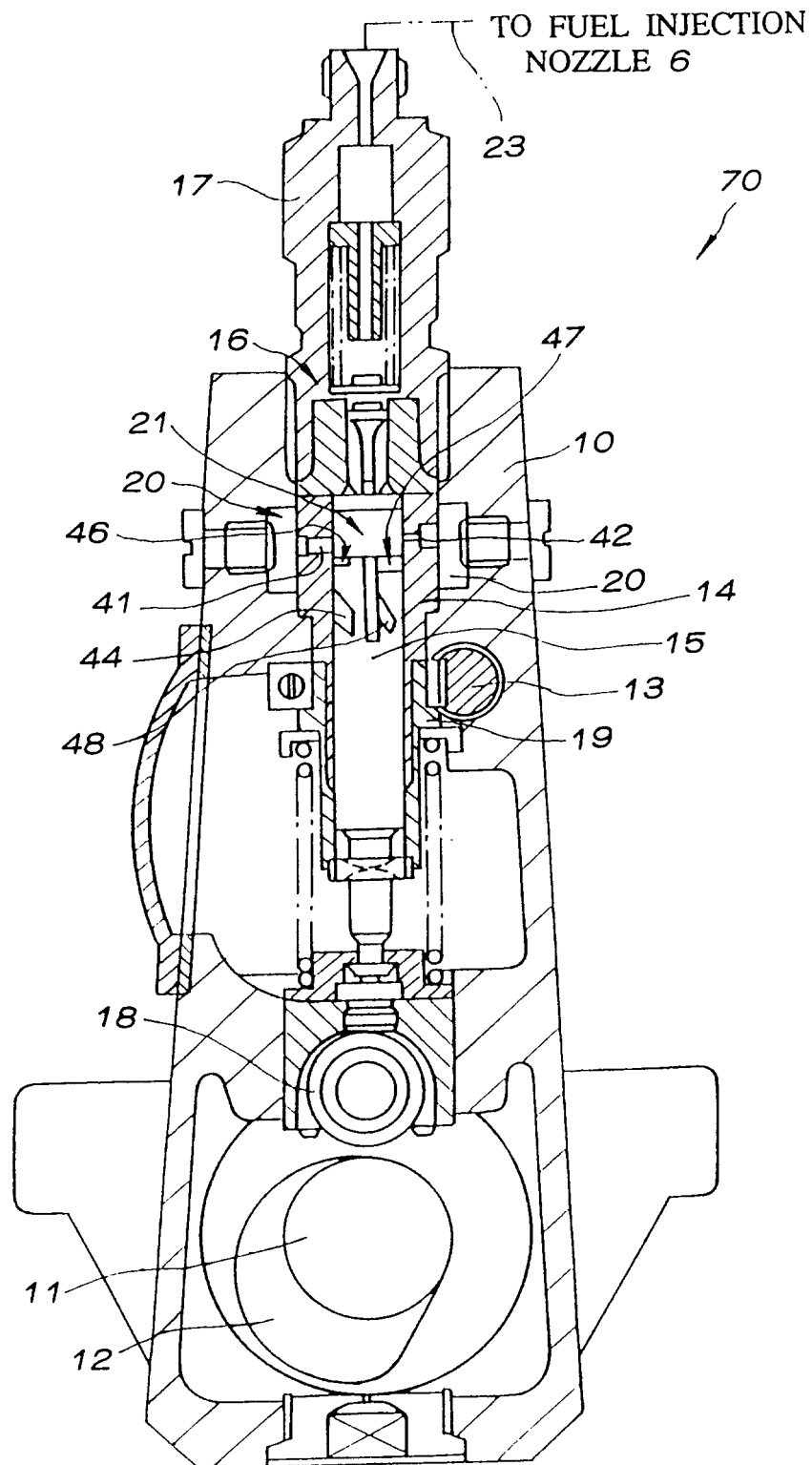


FIG. 23

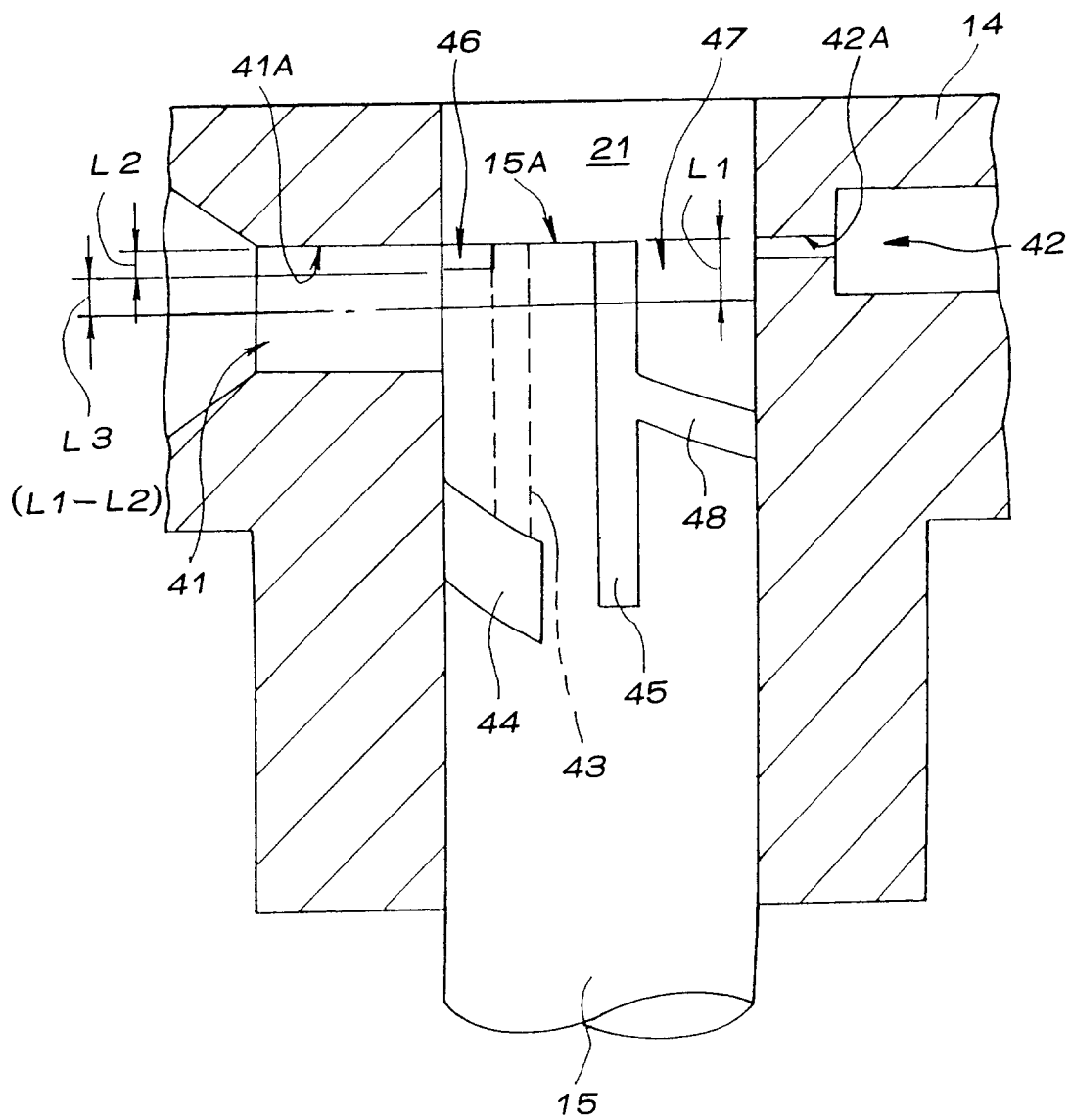


FIG. 24

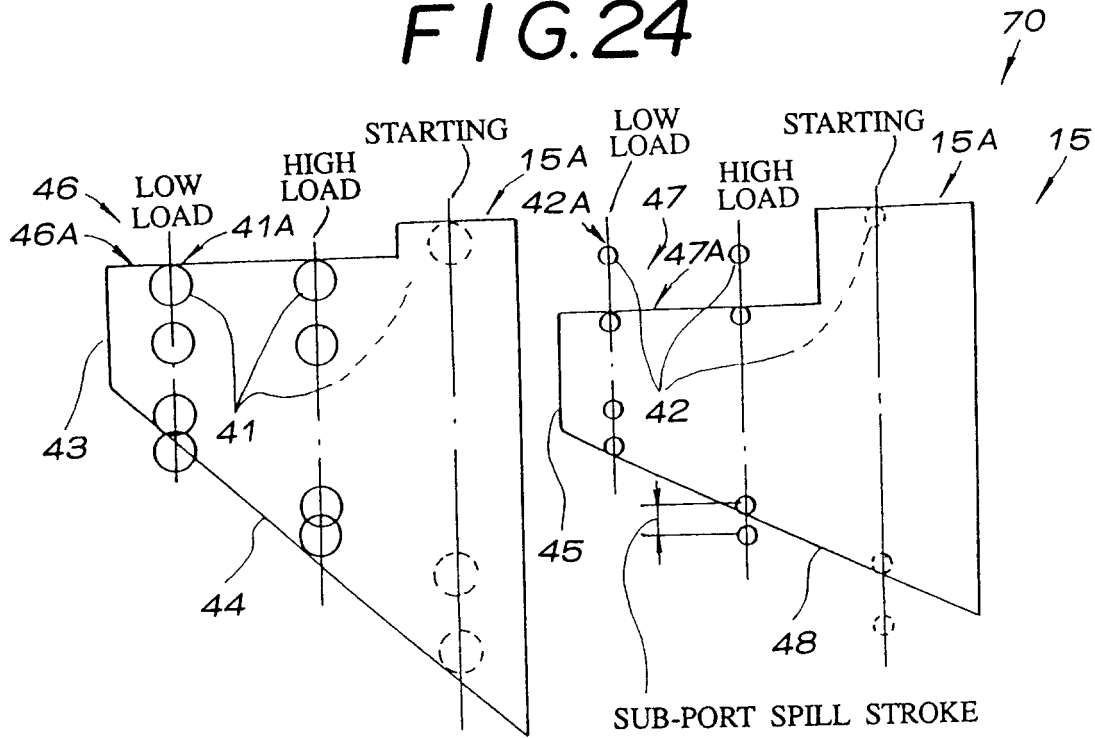


FIG. 25

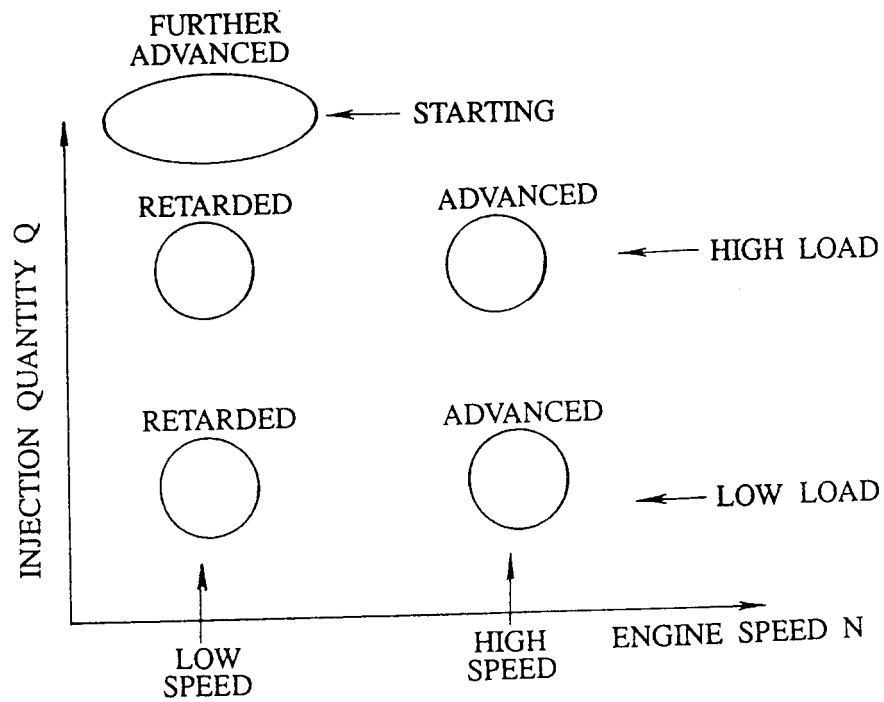


FIG. 26

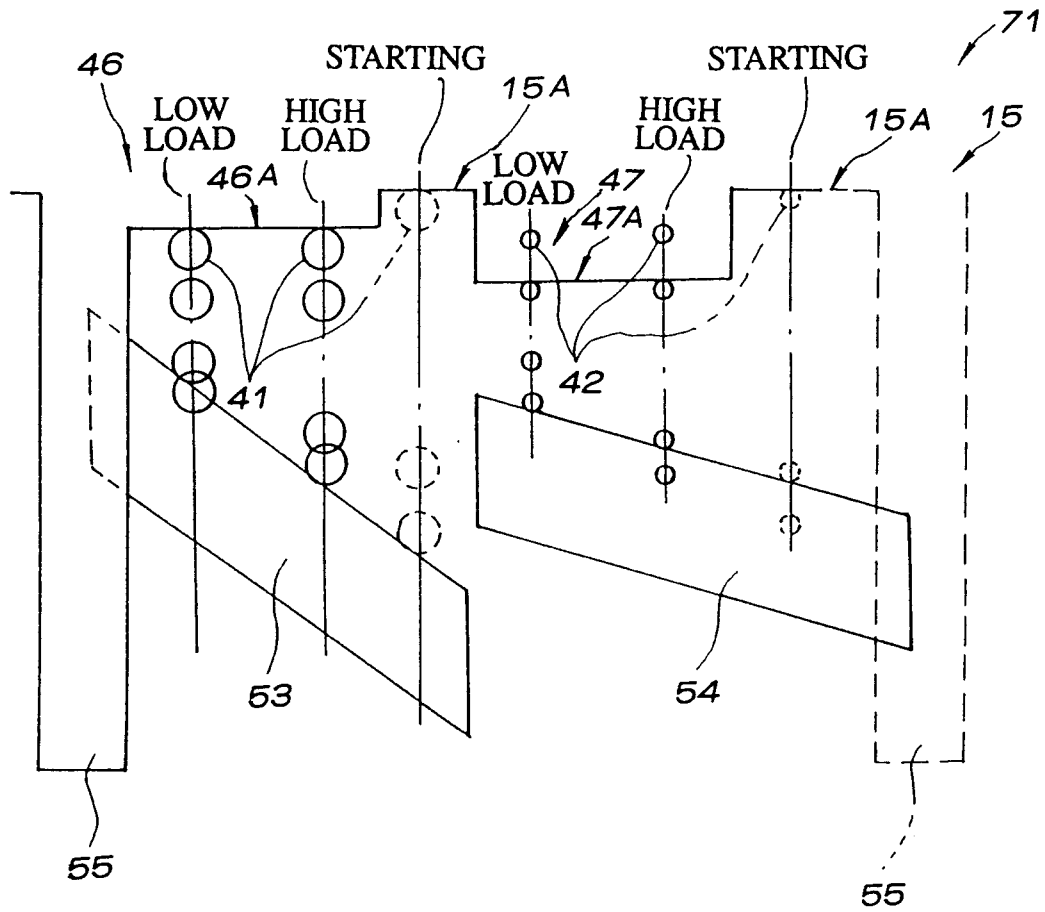


FIG. 27

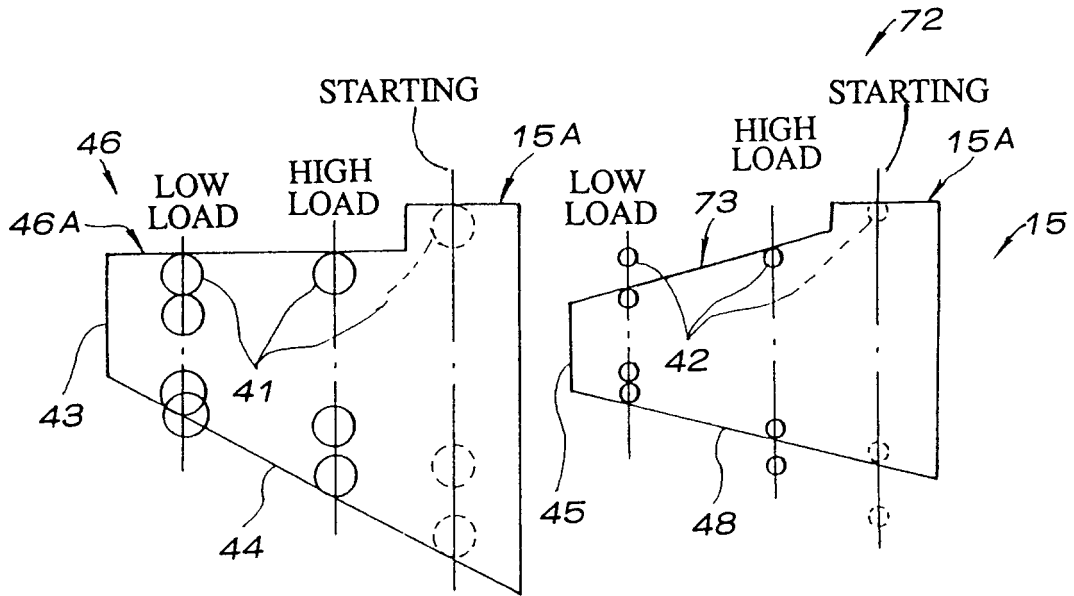


FIG. 28

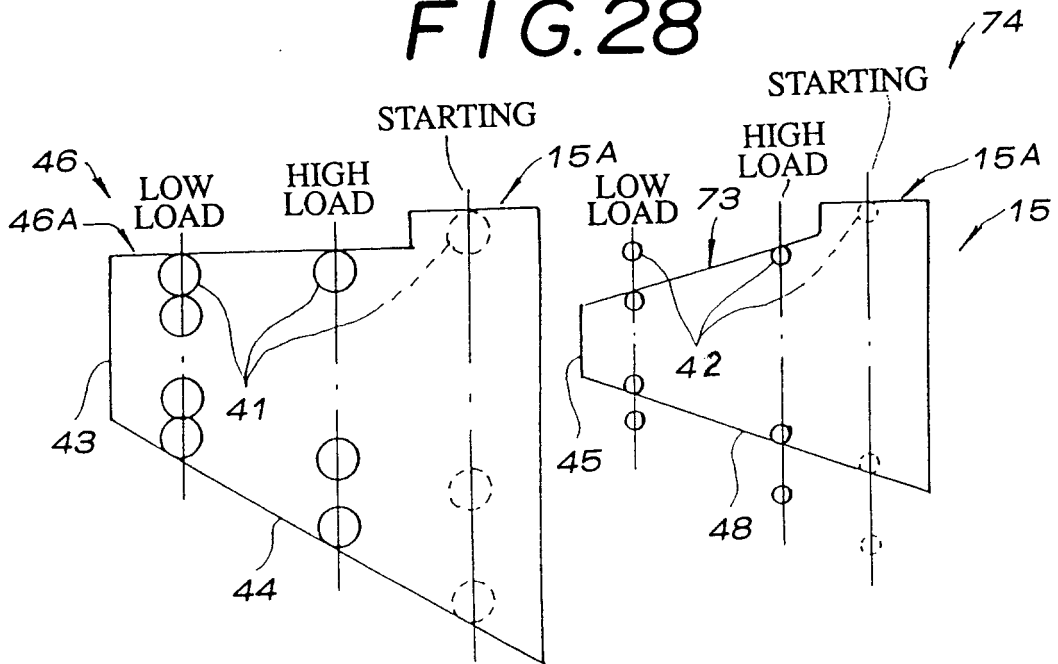


FIG. 29

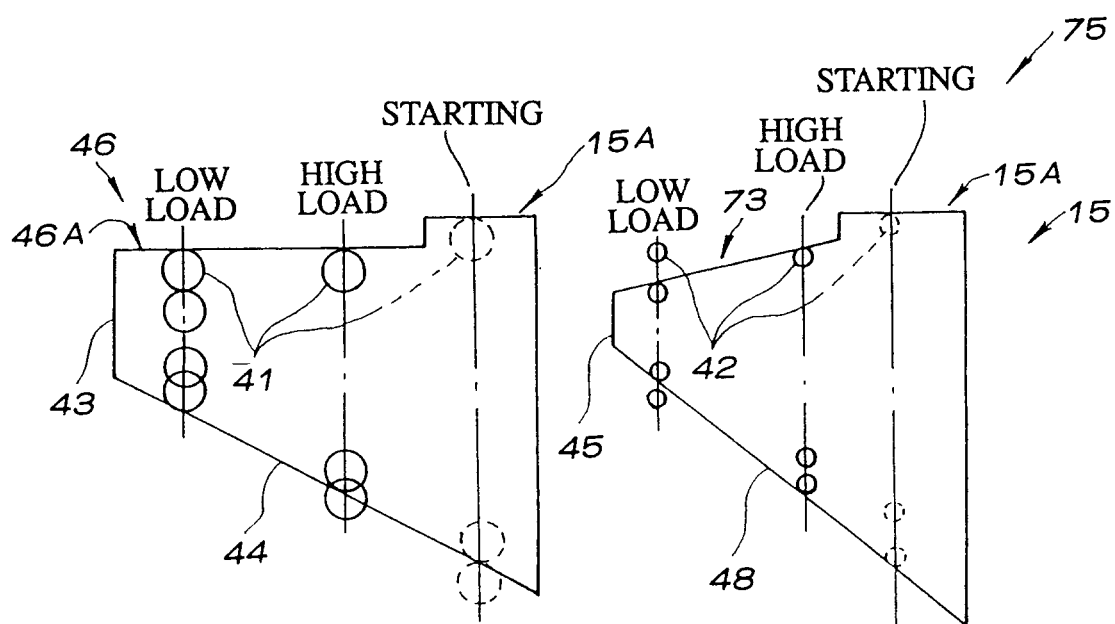


FIG. 30

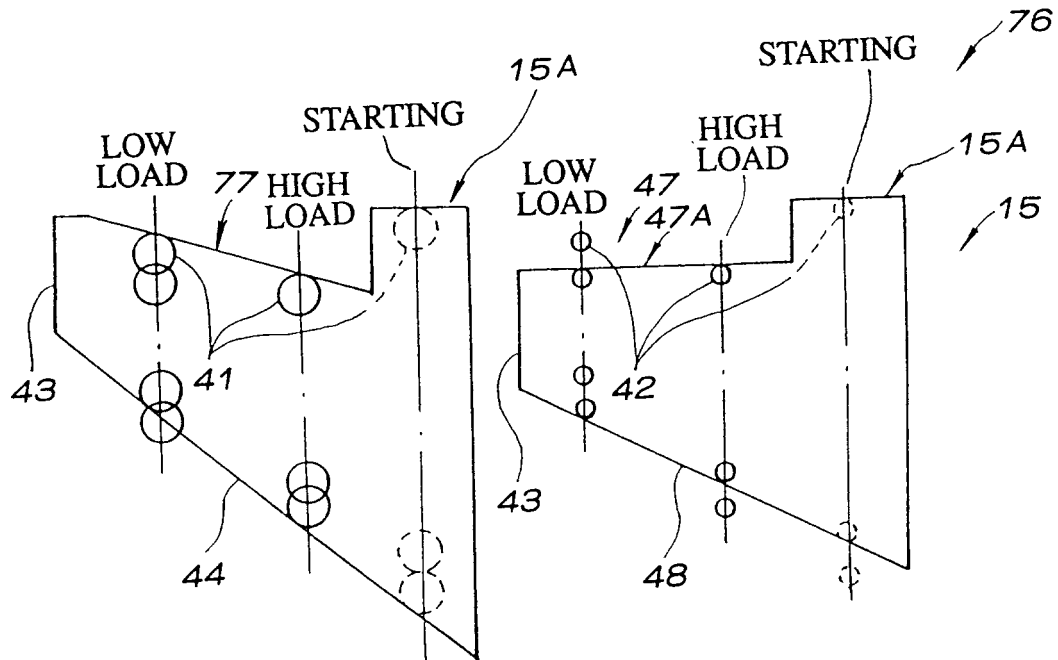


FIG. 31

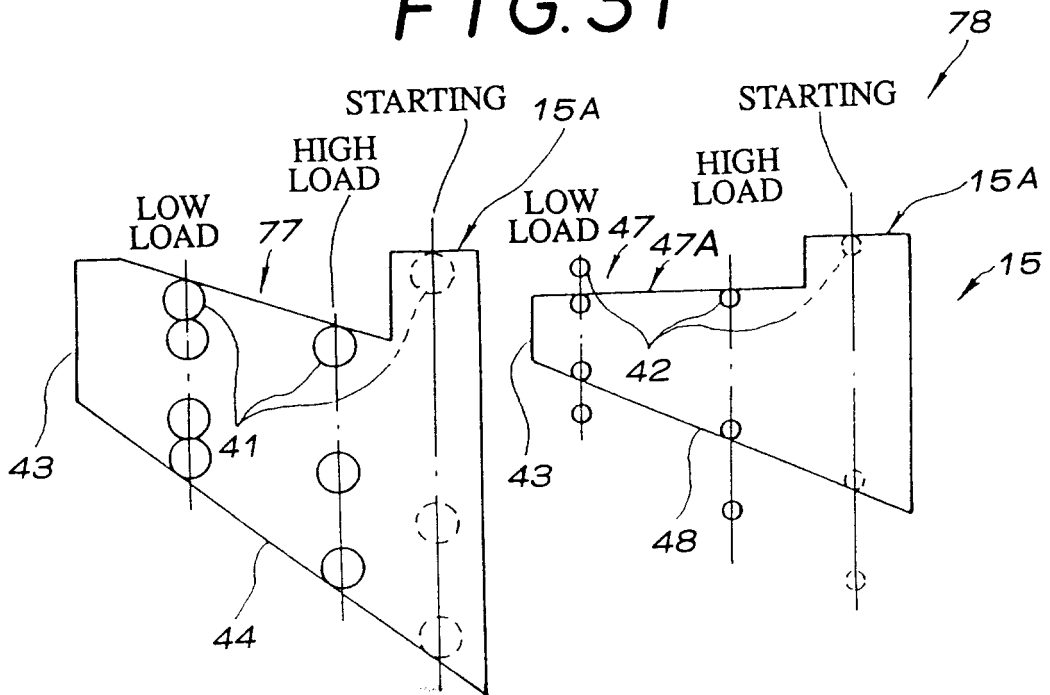


FIG. 32

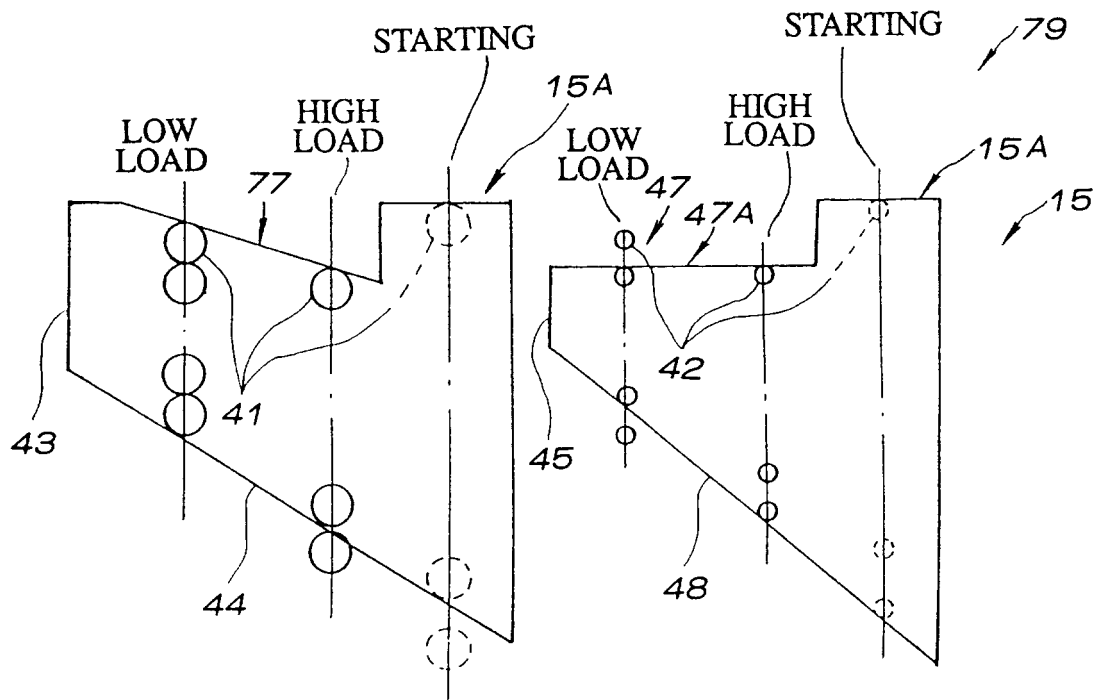


FIG. 33

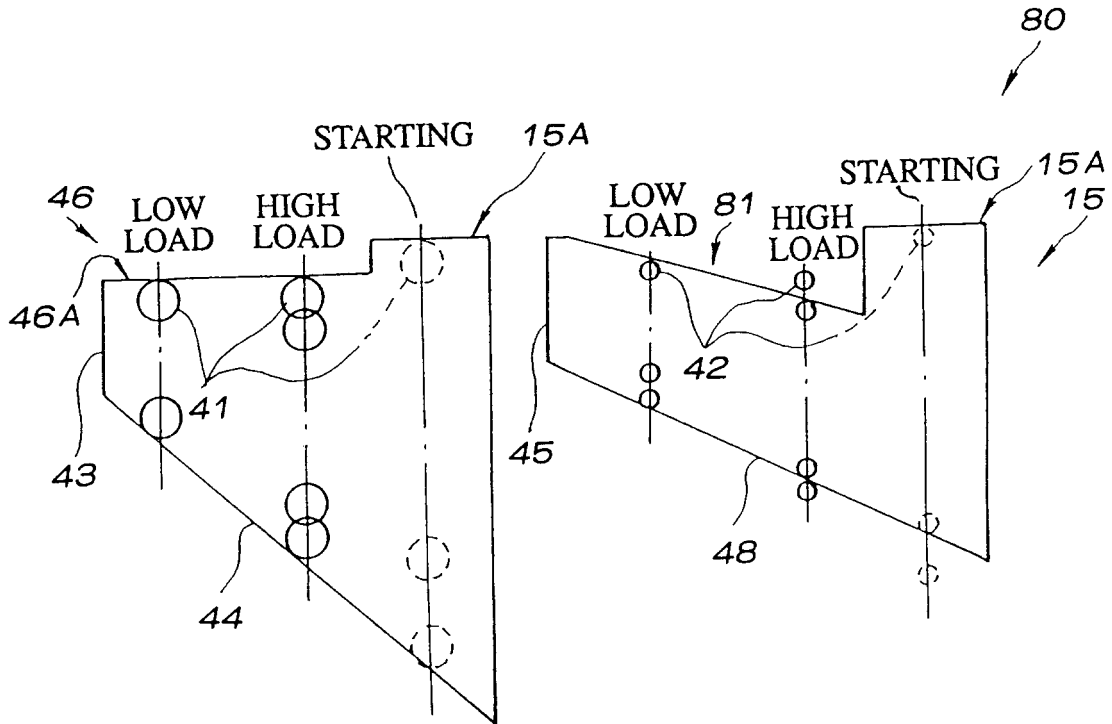


FIG. 34

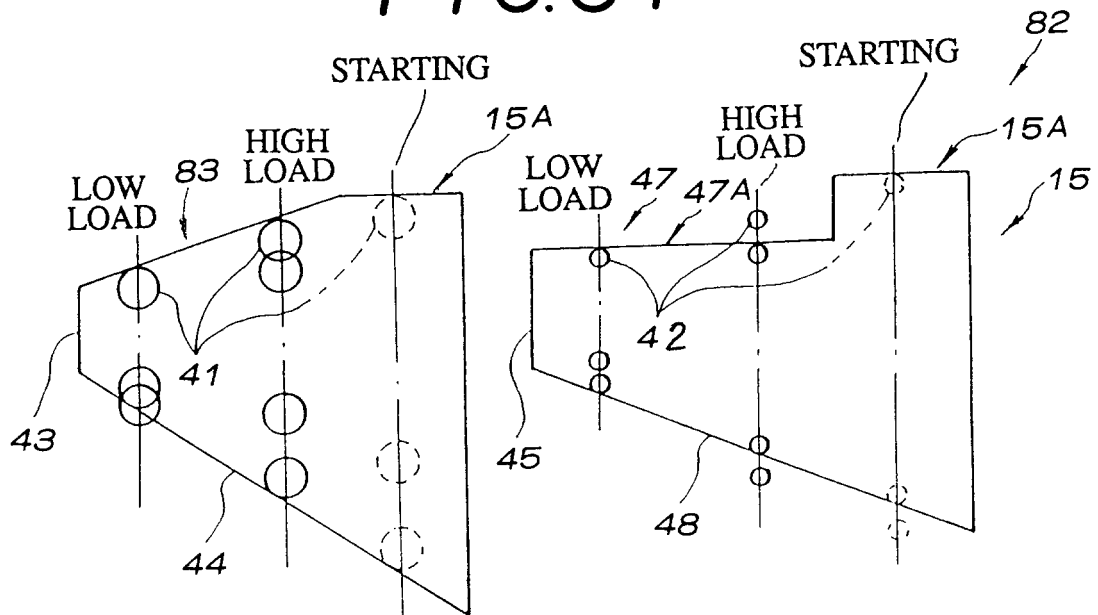


FIG. 35

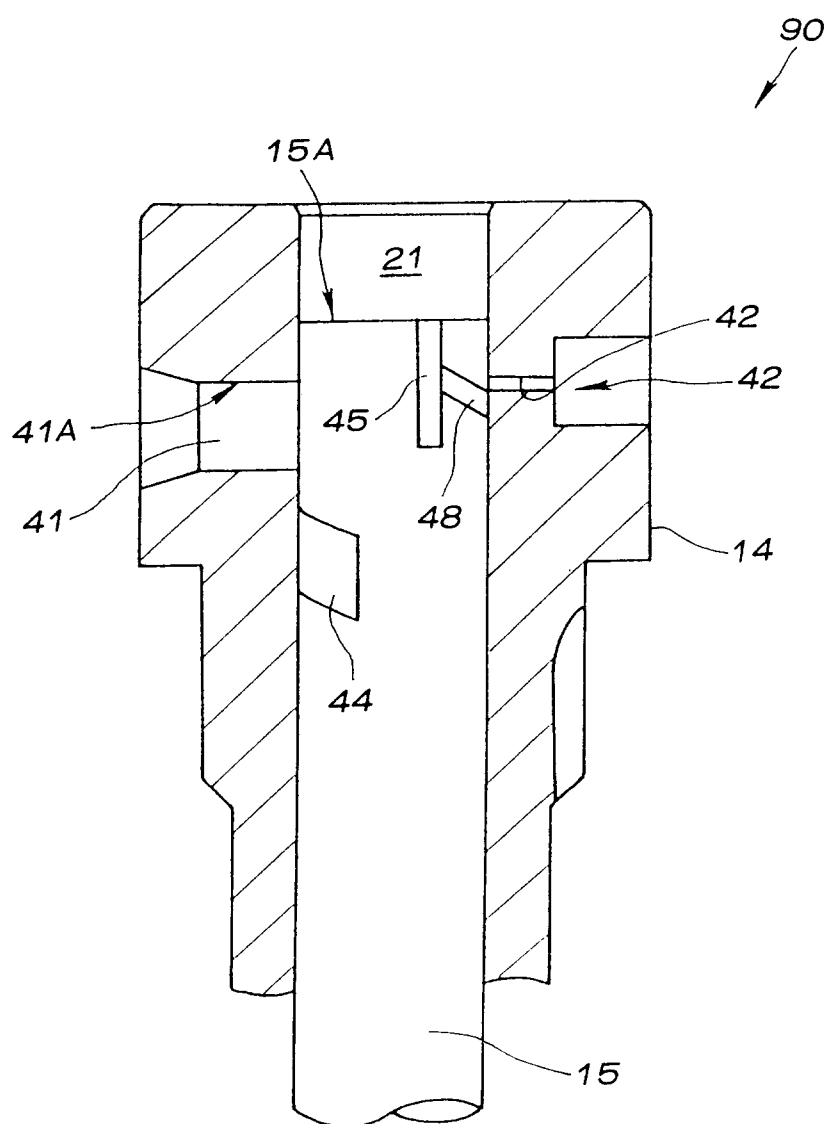


FIG. 36

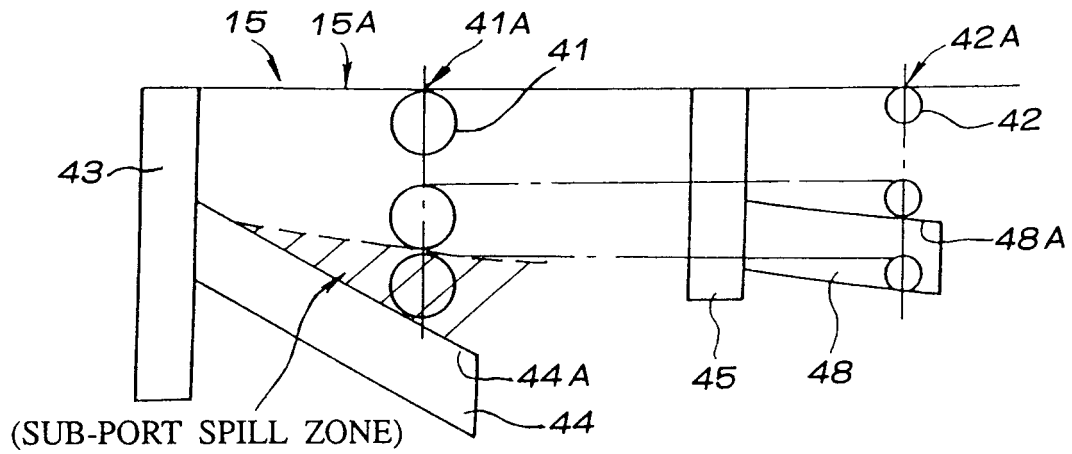


FIG. 37

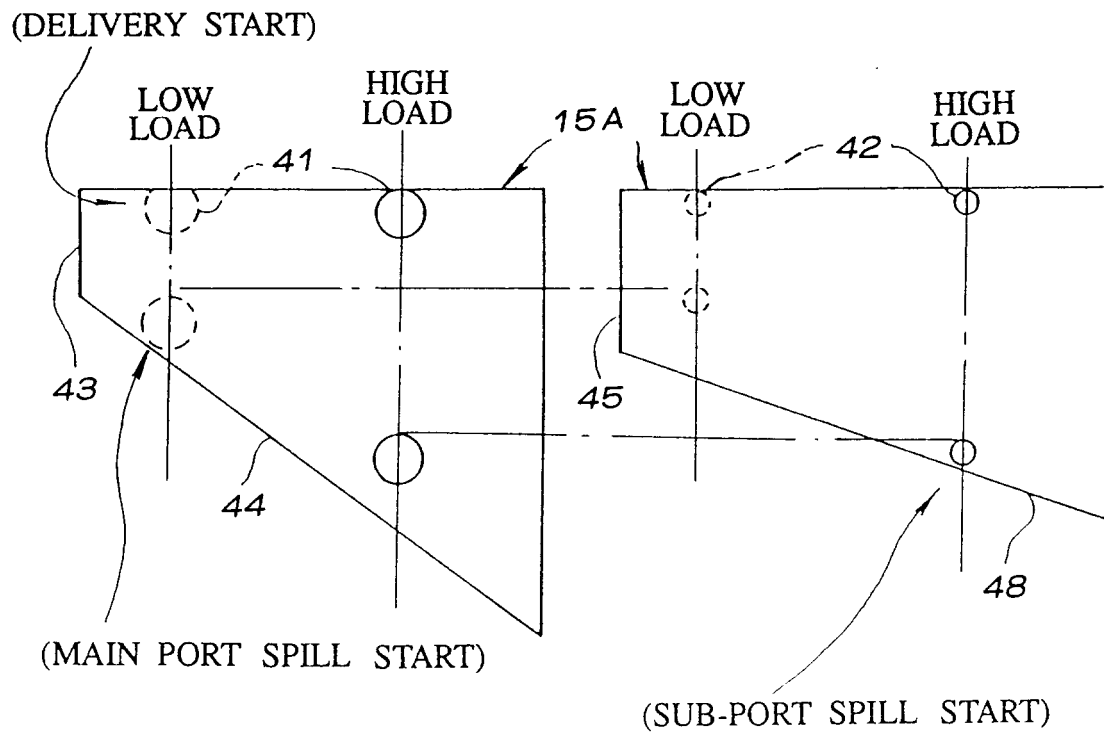


FIG. 38

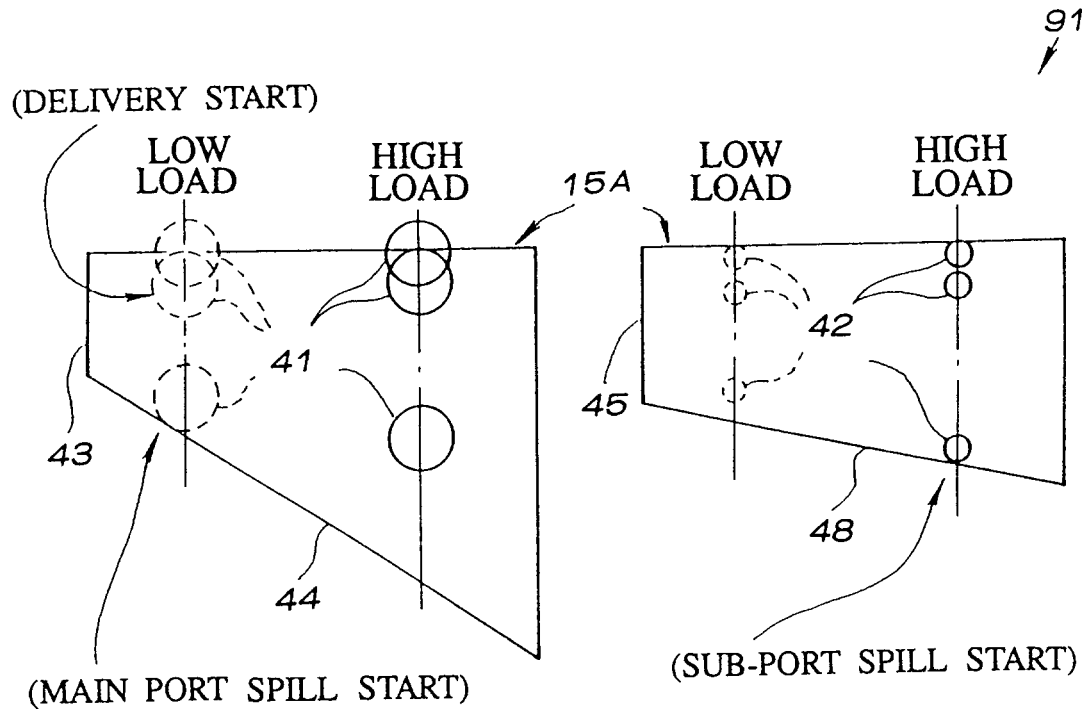


FIG. 39

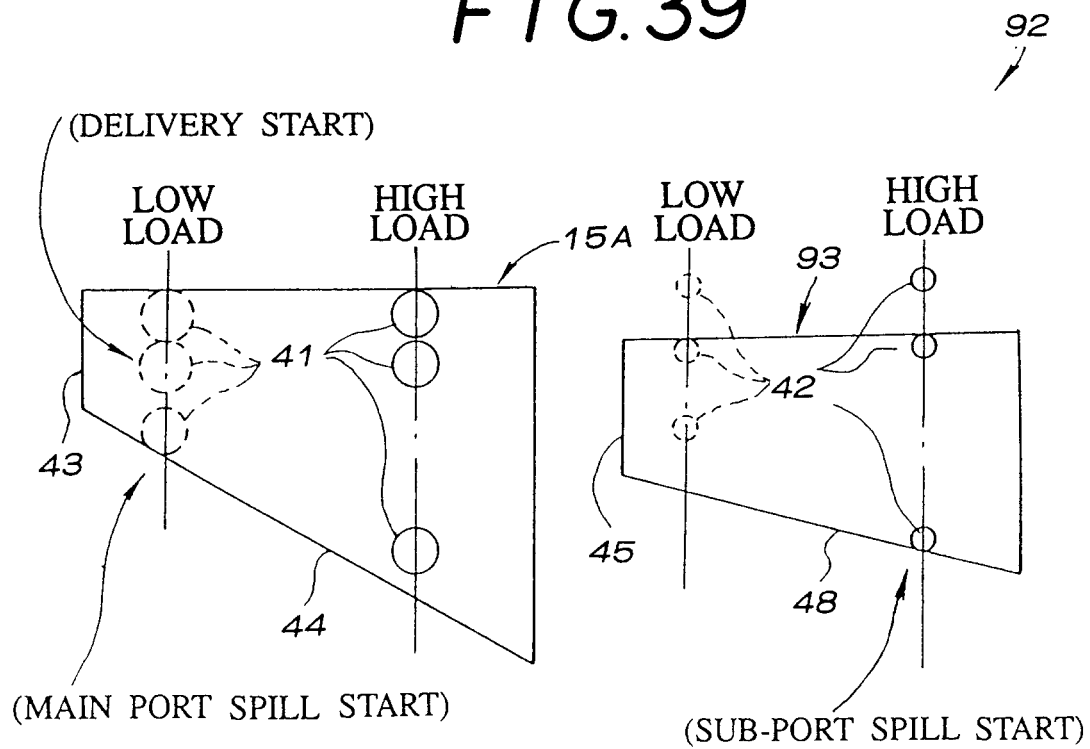


FIG.40

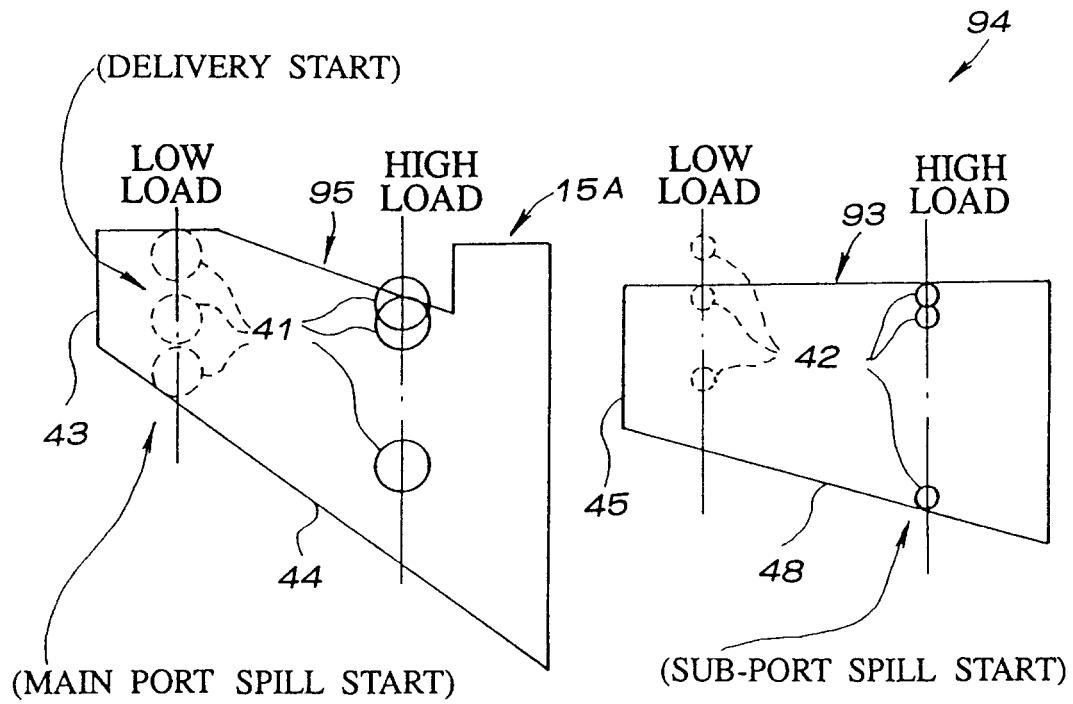


FIG.41

