



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
18.09.2013 Bulletin 2013/38

(51) Int Cl.:
F02M 25/022 (2006.01) F02B 47/04 (2006.01)
F02M 43/02 (2006.01) F02M 43/04 (2006.01)

(21) Application number: **11839282.8**

(86) International application number:
PCT/JP2011/075217

(22) Date of filing: **01.11.2011**

(87) International publication number:
WO 2012/063686 (18.05.2012 Gazette 2012/20)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

- **HIGUCHI, Jun**
Tokyo 108-8215 (JP)
- **TAKAISHI, Tatsuo**
Tokyo 108-8215 (JP)
- **AKAGAWA, Hirokazu**
Tokyo 108-8215 (JP)
- **OSAFUNE, Shinnosuke**
Tokyo 108-8215 (JP)

(30) Priority: **08.11.2010 JP 2010249807**

(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 108-8215 (JP)

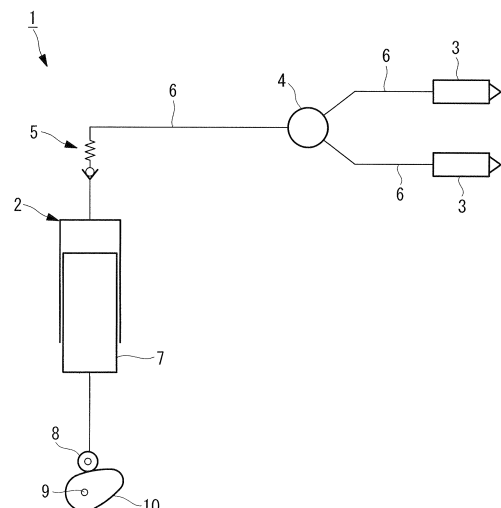
(74) Representative: **HOFFMANN EITLE**
Patent- und Rechtsanwälte
Arabellastrasse 4
81925 München (DE)

(72) Inventors:
• **MURATA, Satoru**
Tokyo 108-8215 (JP)

(54) **FUEL INJECTION DEVICE FOR INTERNAL COMBUSTION ENGINE**

(57) Even when only fuel oil is injected into a cylinder liner, decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of an internal combustion engine are prevented, while increase in dust and black smoke is also prevented. In a fuel injection device (1) for an internal combustion engine, capable of selectively injecting, from a fuel injection valve (3), a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state, or fuel oil only, a cam (10) for lifting up a plunger (7) of a fuel injection pump (2) that pressurizes and feeds the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to the fuel injection valve (3) includes: a first cam for use in lifting up the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state; and a second cam for use in lifting up the fuel oil only.

FIG. 1



Description

{Technical Field}

[0001] The present invention relates to a fuel injection device for an internal combustion engine having a plurality of fuel injection valves mounted on each cylinder.

{Background Art}

[0002] As one example of the fuel injection device for an internal combustion engine having a plurality of fuel injection valves mounted on each cylinder, a device disclosed in PTL 1 is known.

{Citation List}

{Patent Literature}

[0003]

{PTL 1}
Japanese Examined Patent Application, Publication No. Hei 08-11945
{PTL 2}
The Publication of Japanese Patent No. 3615260

{Summary of Invention}

{Technical Problem}

[0004] In recent years, from a viewpoint of environmental protection, ECAs (Emission Control Areas) have been stipulated, and emission of NO_x is limited inside these environmental control areas.

Moreover, regulations of exhaust gas in Emission Control Areas are planned to be tightened in the near future. One way of observing new regulations is, for example, to change a fuel injection mode (operation mode) of a main engine and a generator from injection of fuel oil only to injection of a mixture of fuel oil and water in a multilayered state or in an emulsion state before going into an Emission Control Area as disclosed in the aforementioned PTL 1 and PTL 2.

[0005] However, in the fuel injection valves that inject a mixture of fuel oil and water in a multilayered state or in an emulsion state as disclosed in PTL 1 and PTL 2, an amount of one injection increases, and therefore an aperture of each nozzle hole needs to be made larger than the aperture of the nozzle hole of the fuel injection valves that inject fuel oil only. Accordingly, in the case of PTL 1 and PTL 2, when the fuel injection mode (operation mode) of the main engine and the generator is changed from injection of a mixture of fuel oil and water in a multilayered state or in an emulsion state to injection of fuel oil only upon moving from the range of an Emission Control Area to the outside of the Emission Control Area, fuel injection pressure may be decreased, resulting in dete-

rioration in combustibility and degradation in performance of the combustion engine, while dust and black smoke may be increased.

[0006] The present invention has been made to solve the above-stated problems, and it is an object of the present invention to provide a fuel injection device for an internal combustion engine capable of preventing decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as capable of preventing increase in dust and black smoke.

{Solution to Problem}

[0007] In order to accomplish the above object, the present invention provides the following solutions.

A fuel injection device for an internal combustion engine according to a first aspect of the present invention is a fuel injection device for an internal combustion engine, capable of selectively injecting, from a fuel injection valve, a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state, or fuel oil only, wherein a cam for lifting up a plunger of a fuel injection pump that pressurizes and feeds the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to the fuel injection valve includes: a first cam for use in lifting up the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state; and a second cam for use in lifting up the fuel oil only.

[0008] According to the fuel injection device for an internal combustion engine according to the first aspect of the present invention, when a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state is injected from the fuel injection valve into a cylinder liner, the plunger of the fuel injection pump is lifted up by the first cam, whereas when only the fuel oil is injected from the fuel injection valve into the cylinder liner, the plunger of the fuel injection pump is lifted up by the second cam which lifts up the plunger at a timing and a speed earlier and faster than those of the first cam.

As a consequence, it becomes possible to prevent decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as to prevent increase in dust and black smoke

[0009] A fuel injection device for an internal combustion engine according to a second aspect of the present invention is a fuel injection device for an internal combustion engine, capable of selectively injecting, from a fuel injection valve, a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state, or fuel oil only, wherein a fuel injection pump that pressurizes and feeds the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to the fuel injection valve, is linked to the fuel injection valve through a fuel/water feed pipe, a base end of a branch pipe is connected to an intermediate position

the fuel/water feed pipe, while a leading end of the branch pipe is connected to an accumulator, and a control valve is connected to an intermediate position the branch pipe, the control valve being closed when the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state is injected from the fuel injection valve and being opened when only the fuel oil is injected from the fuel injection valve.

[0010] According to the fuel injection device for an internal combustion engine according to the second aspect of the present invention, when only the fuel oil is injected from the fuel injection valve into the cylinder liner, the control valve is opened, so that injection pressure of the fuel oil injected from the fuel injection valve into the cylinder liner is raised (increased).

As a consequence, it becomes possible to prevent decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as to prevent increase in dust and black smoke.

[0011] A fuel injection device for an internal combustion engine according to a third aspect of the present invention is a fuel injection device for an internal combustion engine, capable of selectively injecting, from a fuel injection valve, a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state, or fuel oil only, wherein the fuel injection valve includes: main and sub nozzles; and a needle valve that is lifted in two stages corresponding to pressure of control air to be fed, so that in a low lift state, the sub nozzle is opened to inject the fuel oil, while in a high lift state, both the main nozzle and the sub nozzle are opened to inject the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state.

[0012] According to the fuel injection device for an internal combustion engine according to the third aspect of the present invention, when only the fuel oil is injected into the cylinder liner, the main nozzle is closed so that the fuel oil is injected only from the sub nozzle.

As a consequence, it becomes possible to prevent decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as to prevent increase in dust and black smoke.

[0013] A fuel injection device for an internal combustion engine according to a fourth aspect of the present invention is a fuel injection device for an internal combustion engine, capable of selectively injecting, from a fuel injection valve, a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state, or fuel oil only, wherein at least two fuel injection pumps that pressurize and feed the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to the fuel injection valve, a fuel/water feed pipe that feeds the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to these fuel injection pumps, and a control valve that is connected to an intermediate position the

fuel/water feed pipe are connected to each other, the control valve being closed when the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state is injected from the fuel injection valve and being opened when only the fuel oil is injected from the fuel injection valve.

[0014] According to the fuel injection device for an internal combustion engine according to the fourth aspect of the present invention, when only the fuel oil is injected into the cylinder liner, the pressurized fuel oil is fed from two fuel injection pumps to the fuel injection valve.

As a consequence, it becomes possible to prevent decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as to prevent increase in dust and black smoke.

[0015] An internal combustion engine according to a fifth aspect of the present invention includes any one of the fuel injection devices for an internal combustion engine described in the foregoing.

[0016] In the combustion engine according to the fifth aspect of the present invention, the fuel injection device for an internal combustion engine is mounted (provided), which is capable of preventing decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as capable of preventing increase in dust and black smoke even when only the fuel oil is injected into the cylinder liner.

As a consequence, it becomes possible to enhance combustibility in a cylinder in the case of injecting only the fuel oil into the cylinder liner and to reduce soot and black smoke discharged from the cylinder.

[0017] A ship according to a sixth aspect of the present invention includes the combustion engine.

[0018] According to the ship in the sixth aspect of the present invention, an internal combustion engine is mounted (provided), which is capable of preventing decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as capable of preventing increase in dust and black smoke even when only the fuel oil is injected into the cylinder liner.

As a consequence, it becomes possible to enhance fuel efficiency of the entire ship so that a cruising range can be extended, and to also become possible to reduce soot and black smoke discharged from a funnel (smokestack).

{Advantageous Effects of Invention}

[0019] The fuel injection device for an internal combustion engine according to the present invention has the effects that decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine can be prevented and increase in dust and black smoke can also be prevented.

{Brief Description of Drawings}

[0020]

{Fig. 1}

Fig. 1 is a schematic configuration view showing a fuel injection device for an internal combustion engine according to a first embodiment of the present invention.

{Fig. 2}

Fig. 2 shows a graphic chart illustrating a relationship between a cam lift amount of a cam shown in Fig. 1 and a crank angle (cam angle).

{Fig. 3}

Fig. 3 is a schematic configuration view showing a fuel injection device for an internal combustion engine according to a second embodiment of the present invention.

{Fig. 4}

Fig. 4 is a schematic configuration view showing a fuel injection valve according to a third embodiment of the present invention, in which a main nozzle and a sub nozzle are closed.

{Fig. 5}

Fig. 5 is a schematic configuration view showing the fuel injection valve according to the third embodiment of the present invention, in which a mixture of fuel oil and water in a multilayered state or in an emulsion state is being injected.

{Fig. 6}

Fig. 6 is a schematic configuration view showing the fuel injection valve according to the third embodiment of the present invention, in which only the fuel oil is being injected.

{Fig. 7}

Fig. 7 is a schematic configuration view showing a fuel injection device for an internal combustion engine according to a fourth embodiment of the present invention.

{Fig. 8}

Fig. 8 is a view explaining a function of the fuel injection device for an internal combustion engine according to the present invention.

{Fig. 9}

Fig. 9 is a view explaining a function of the fuel injection device for an internal combustion engine according to the present invention.

{Description of Embodiments}

(First Embodiment)

[0021] A fuel injection device for an internal combustion engine according to the first embodiment of the present invention will be explained with reference to Figs. 1 and 2.

Fig. 1 is a schematic configuration view showing a fuel injection device for an internal combustion engine ac-

cording to the present embodiment. Fig. 2 shows a graphic chart illustrating the relationship between a cam lift amount of a cam shown in Fig. 1 and a crank angle (cam angle).

It is to be noted that the fuel injection device for an internal combustion engine according to the present invention is configured to be mounted on an internal combustion engine (not shown) such as a large size diesel engine for a ship.

[0022] As shown in Fig. 1, a fuel injection device 1 for an internal combustion engine according to the present embodiment is a fuel injection device capable of changing a fuel injection mode (operation mode) of a main engine and a generator, as disclosed in PTL 1 for example, from injection of fuel oil only to injection of a mixture of fuel oil and water in a multilayered state or in an emulsion state before going into an Emission Control Area from the outside of the Emission Control Area, and capable of changing the fuel injection mode (operation mode) of the main engine and the generator from injection of the mixture of fuel oil and water in a multilayered state or in an emulsion state to injection of the fuel oil only upon moving from the range of the Emission Control Area to the outside of the Emission Control Area. The fuel injection device 1 includes one fuel injection pump 2 and at least one fuel injection valve (two in this embodiment) 3, so that a pair of them is placed for each cylinder.

[0023] In Fig. 1, there are shown a distributor 4, a check valve 5, and a fuel/water feed pipe (high pressure pipe) 6. Configurations of the fuel injection pump 2, the fuel injection valve 3, the distributor 4 and the check valve 5 are not particularly limited, and configurations of publicly known fuel injection pumps, fuel injection valves, distributors, and check valves may be used therefor.

[0024] Now, the fuel injection pump 2 according to the present embodiment is a Bosch fuel injection pump including a plunger 7 and a tappet 8 and is attached onto a cam shaft 9 of each cylinder via a flange (not shown). A cam 10 includes: a cam (first cam) for inside of ECA that lifts up the plunger 7 and the tappet 8 at a timing shown with a solid line in Fig. 2 in the inside of an Emission Control Area; and a cam (second cam) for outside of ECA that lifts up the plunger 7 and the tappet 8 at a timing shown with a broken line in Fig. 2 in the outside of the Emission Control Area. The cam 10 is placed on a cam shaft 9 side by side with a reversing cam.

[0025] The cam for inside of ECA is a cam, as shown in Fig. 8 or 9 for example, which has a relationship between a cam lift amount and a crank angle (cam angle) that is suitable for injecting a mixture of fuel oil and water in a multilayered state or in an emulsion state. The cam for outside of ECA is a cam that lifts up the plunger 7 and the tappet 8 at a speed faster than that of the cam for inside of ECA.

[0026] According to the fuel injection device 1 for an internal combustion engine in the present embodiment, when a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state is injected from

the fuel injection valve 3 into a cylinder liner, the plunger 7 of the fuel injection pump 2 is lifted up by the cam for inside of ECA (first cam), whereas when only the fuel oil is injected from the fuel injection valve 3 into the cylinder liner, the plunger 7 of the fuel injection pump 2 is lifted up by the cam for outside of ECA (second cam) that lifts up the plunger 7 at a speed faster than that of the cam for inside of ECA.

As a consequence, it becomes possible to prevent decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as to prevent increase in dust and black smoke.

(Second Embodiment)

[0027] A fuel injection device for an internal combustion engine according to the second embodiment of the present invention will be explained with reference to Fig. 3.

Fig. 3 is a schematic configuration view showing the fuel injection device for an internal combustion engine according to the present embodiment.

[0028] As shown in Fig. 3, a fuel injection device 21 for an internal combustion engine according to the present embodiment is different from that of the first embodiment in that a cam for inside of ECA 22 is provided instead of the cam 10, a base end (one end) of a branch pipe 23 is connected to the intermediate position of a fuel/water feed pipe (high pressure pipe) 6 positioned between a check valve 5 and a distributor 4 while a leading end (the other end) of the branch pipe 23 is connected to an accumulator 24. Since other component members are identical to those of the first embodiment described above, a description of these component members will be omitted herein.

It is to be noted that component members identical to those of the first embodiment described above are designated by identical reference signs to omit a description thereof.

[0029] A control valve 25 is connected to an intermediate position the branch pipe 23, the control valve 25 being closed when a mixture of fuel oil and water in a multilayered state or in an emulsion state is injected from the fuel injection valve 3 and being opened when only the fuel oil is injected from the fuel injection valve 3. The control valve 25 is also opened and closed in response to a command signal from a controller (not shown) that determines (grasps) whether a fuel injection mode (operation mode) of a main engine and a generator is a mode of injecting a mixture of fuel oil and water in a multilayered state or in an emulsion state from the fuel injection valve 3 or it is a mode of injecting fuel oil only from the fuel injection valve 3.

[0030] According to the fuel injection device 21 for an internal combustion engine in the present embodiment, when only the fuel oil is injected from the fuel injection valve 3 into a cylinder liner, the control valve 25 is opened,

so that injection pressure of the fuel oil injected from the fuel injection valve 3 into a cylinder is raised (increased). As a consequence, it becomes possible to prevent decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as to prevent increase in dust and black smoke.

(Third Embodiment)

[0031] A fuel injection device for an internal combustion engine according to the third embodiment of the present invention will be explained with reference to Figs. 4 to 6.

Fig. 4 is a schematic configuration view showing a fuel injection valve according to the present embodiment. Fig. 5 is a view showing a mixture of fuel oil and water in a multilayered state or in an emulsion being injected. Fig. 6 is a view showing only the fuel oil being injected.

[0032] As shown in Figs. 4 to 6, a fuel injection device 31 for an internal combustion engine according to the present embodiment is different from that of the first embodiment described above in that a cam for inside of ECA 22 (see Fig. 3) is provided instead of the cam 10 and a fuel injection valve 32 is provided instead of the fuel injection valve 3. Since other component members are identical to those of the first embodiment described above, a description of these component members will be omitted herein.

It is to be noted that component members identical to those of the first embodiment described above are designated by identical reference signs to omit a description thereof.

[0033] When the plunger 7 and the tappet 8 are not lifted up by the cam for inside of ECA 22 and so the fuel pressure is not raised in the fuel injection valve 32, a needle valve 33 sits onto a sheet surface 35 of an injection nozzle portion 34 as shown in Fig. 4 so as to block inflow of a mixture of fuel oil and water in a multilayered state or in an emulsion state, or fuel oil, from a nozzle chamber 36 to a sub nozzle 37 and a main nozzle 38 and to block injection of the mixture of fuel oil and water in a multilayered state or in an emulsion state, or the fuel oil, from the sub nozzle 37 and the main nozzle 38.

When the fuel pressure is raised by the plunger 7 and the tappet 8 being lifted up by the cam for inside of ECA 22, and operating air is also fed to a top portion, the needle valve 33 is raised (lifted) from the sheet surface 35 of the injection nozzle portion 34 by a length of $L_1 + L_2$ as shown in Fig. 5 so as to allow inflow of the mixture of fuel oil and water in a multilayered state or in an emulsion state from inside the nozzle chamber 36 to the sub nozzle 37 and the main nozzle 38 and to allow injection of the mixture of fuel oil and water in a multilayered state or in an emulsion state from the sub nozzle 37 and the main nozzle 38.

In this configuration, when the fuel pressure is raised by the plunger 7 and the tappet 8 being lifted up by the cam

for inside of ECA 22, and operating air fed to the top portion is blocked, the needle valve 33 is raised by a length of L1 from the sheet surface 35 of the injection nozzle portion 34 as shown in Fig. 6 so as to allow inflow of the fuel oil from inside the nozzle chamber 36 to the sub nozzle 37 and to allow injection of the fuel oil only from the sub nozzle 37.

[0034] According to the fuel injection device 31 for an internal combustion engine in the present embodiment, when only the fuel oil is injected into the cylinder liner, the main nozzle 38 is closed so that the fuel oil is injected only from the sub nozzle 37.

As a consequence, it becomes possible to prevent decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as to prevent increase in dust and black smoke.

(Fourth Embodiment)

[0035] A fuel injection device for an internal combustion engine according to the fourth embodiment of the present invention will be explained with reference to Fig. 7.

Fig. 7 is a schematic configuration view showing the fuel injection device for an internal combustion engine according to the present embodiment.

[0036] As shown in Fig. 7, a fuel injection device 41 for an internal combustion engine according to the present embodiment is different from that of the first embodiment described above in that a cam for inside of ECA 22 is provided instead of the cam 10 and two fuel injection pumps 2 are provided. Since other component members are identical to those of the first embodiment described above, a description of these component members will be omitted herein.

It is to be noted that component members identical to those of the first embodiment described above are designated by identical reference signs to omit a description thereof.

[0037] The fuel injection pumps 2 according to the present embodiment are configured such that both the pumps are used when only fuel oil is injected from the fuel injection valve 3, whereas when a mixture of fuel oil and water in a multilayered state or in an emulsion state is injected from the fuel injection valve 3, only one pump (left-side pump in Fig. 7 in the present embodiment) is used. More specifically, when the mixture of fuel oil and water in a multilayered state or in an emulsion state is injected from the fuel injection valve 3, a rack position of a fuel rack (not shown) of the other fuel injection pump 2 (right-side pump in Fig. 7 in the present embodiment) is set to "0 (zero)" and a control valve 43, which is connected to the intermediate position of a fuel/water feed pipe 42 that feeds the mixture of fuel oil and water in a multilayered state or in an emulsion state to the other fuel injection pump 2, is closed. The rack position of the fuel rack of the other fuel injection pump 2 and the control

valve 43 are operated and opened/closed in response to command signals from a controller (not shown) that determines (grasps) whether a fuel injection mode (operation mode) of a main engine and a generator is a mode of injecting the mixture of fuel oil and water in a multilayered state or in an emulsion state from the fuel injection valve 3 or it is a mode of injecting fuel oil only from the fuel injection valve 3.

[0038] According to the fuel injection device 41 for an internal combustion engine in the present embodiment, when only the fuel oil is injected into a cylinder liner, the pressurized fuel oil is fed from two fuel injection pumps 2 to the fuel injection valve 3.

As a consequence, it becomes possible to prevent decrease in fuel injection pressure, deterioration in combustibility, and degradation in performance of the internal combustion engine as well as to prevent increase in dust and black smoke.

[0039] It should be understood that the present invention is not limited to the embodiments described above and appropriate deformations and modifications are possible where necessary.

For example, although the foregoing embodiments have been described with two fuel injection valves 3 being provided for every fuel injection pump 2 as a specific example, three or four fuel injection valves 3 may be provided for every fuel injection pump 2. The present invention is not limited by the number of the fuel injection valves 3. Moreover, in the foregoing embodiments, other inert substances may be used in place of water.

[0040] Further, at least one fuel injection valve 3 for injecting fuel oil only and at least one fuel injection valve 3 for injecting a mixture of fuel oil and water in a multilayered state or in an emulsion state may be configured to be mounted on each cylinder, so that the fuel injection valves may be switched in accordance with the fuel injection mode (operation mode) of the main engine and the generator.

Furthermore, the combustion engine itself may be constituted as an electronically- controlled engine and be controlled so as to raise (increase) injection pressure of fuel oil when only the fuel oil is injected from the fuel injection valve 3.

{Reference Signs List}

[0041]

- | | |
|----|---|
| 1 | Fuel injection device for an internal combustion engine |
| 2 | Fuel injection pump |
| 3 | Fuel injection valve |
| 6 | Fuel/water feed pipe |
| 7 | Plunger |
| 10 | Cam |
| 21 | Fuel injection device for an internal combustion engine |
| 22 | Cam for inside of ECA (first cam) |

- 23 Branch pipe
- 24 Accumulator
- 25 Control valve
- 31 Fuel injection device for an internal combustion engine
- 32 Fuel injection valve
- 33 Needle valve
- 37 Sub nozzle
- 38 Main nozzle
- 41 Fuel injection device for an internal combustion engine
- 42 Fuel/water feed pipe
- 43 Control valve

stance in a multilayered state or in an emulsion state, or fuel oil only, wherein the fuel injection valve includes:

main and sub nozzles; and
a needle valve that is lifted in two stages corresponding to pressure of control air to be fed, so that in a low lift state, the sub nozzle is opened to inject the fuel oil, while in a high lift state, both the main nozzle and the sub nozzle are opened to inject the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state.

Claims

1. A fuel injection device for an internal combustion engine, capable of selectively injecting, from a fuel injection valve, a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state, or fuel oil only, wherein
a cam for lifting up a plunger of a fuel injection pump that pressurizes and feeds the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to the fuel injection valve includes:

a first cam for use in lifting up the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state; and
a second cam for use in lifting up the fuel oil only.

2. A fuel injection device for an internal combustion engine, capable of selectively injecting, from a fuel injection valve, a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state, or fuel oil only, wherein
a fuel injection pump that pressurizes and feeds the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to the fuel injection valve, is linked to the fuel injection valve through a fuel/water feed pipe,
a base end of a branch pipe is connected to an intermediate position the fuel/water feed pipe, while a leading end of the branch pipe is connected to an accumulator, and
a control valve is connected to an intermediate position the branch pipe, the control valve being closed when the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state is injected from the fuel injection valve and being opened when only the fuel oil is injected from the fuel injection valve.

3. A fuel injection device for an internal combustion engine, capable of selectively injecting, from a fuel injection valve, a mixture of fuel oil and an inert sub-

4. A fuel injection device for an internal combustion engine, capable of selectively injecting, from a fuel injection valve, a mixture of fuel oil and an inert substance in a multilayered state or in an emulsion state, or fuel oil only, wherein

at least two fuel injection pumps that pressurize and feed the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to the fuel injection valve,

a fuel/water feed pipe that feeds the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state, or the fuel oil to these fuel injection pumps, and

a control valve that is connected to an intermediate position the fuel/water feed pipe are connected to each other, the control valve being closed when the mixture of fuel oil and the inert substance in a multilayered state or in an emulsion state is injected from the fuel injection valve and being opened when only the fuel oil is injected from the fuel injection valve.

5. An internal combustion engine comprising a fuel injection device for an internal combustion engine according to any one of claims 1 to 4.

6. A ship comprising an internal combustion engine according to claim 5.

FIG. 1

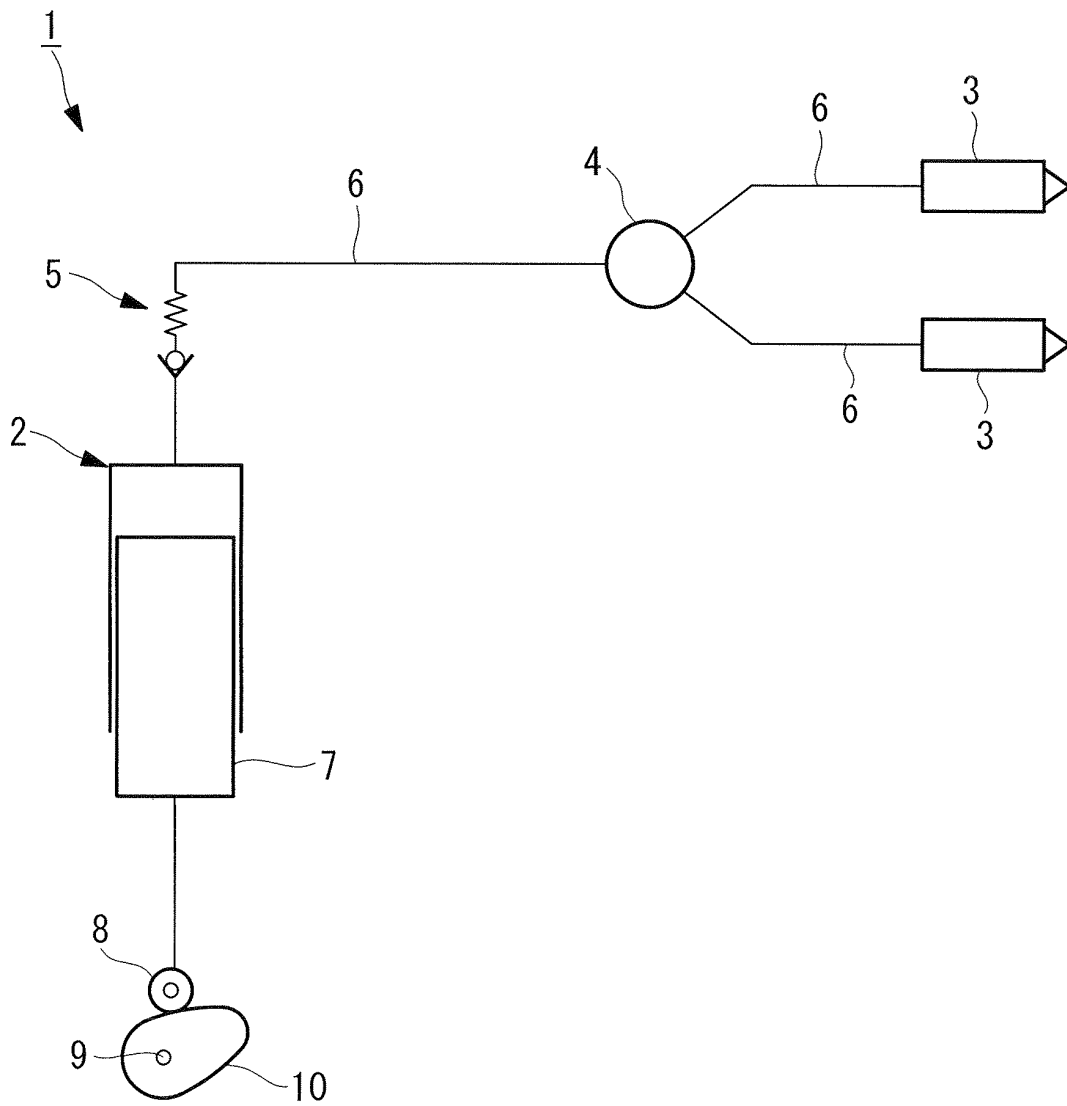


FIG. 2

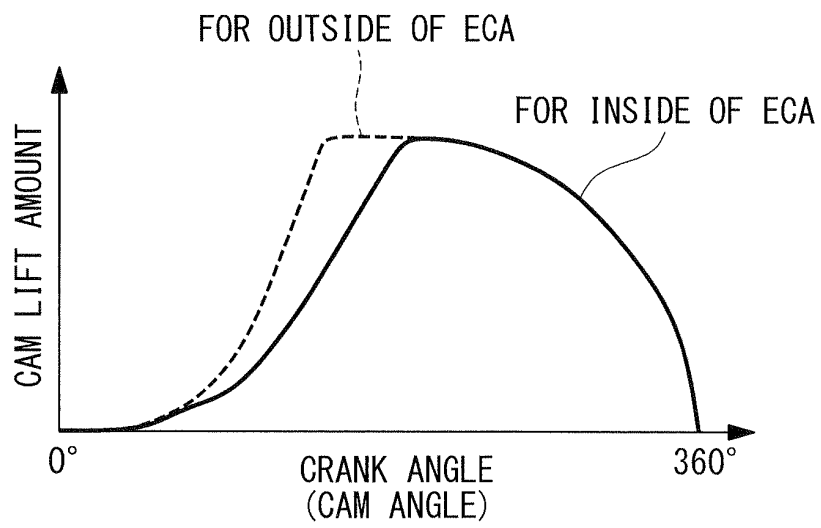


FIG. 3

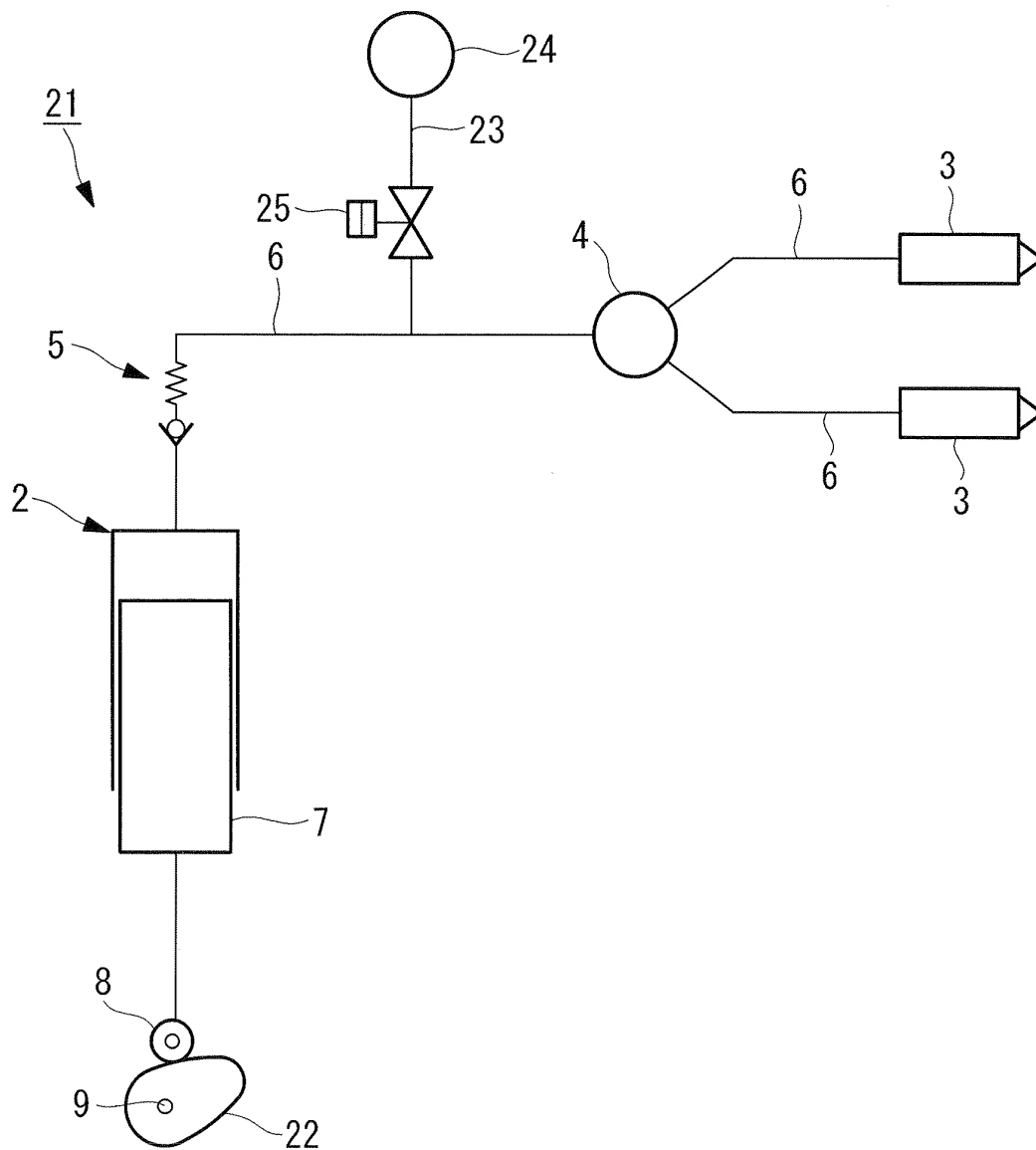


FIG. 4

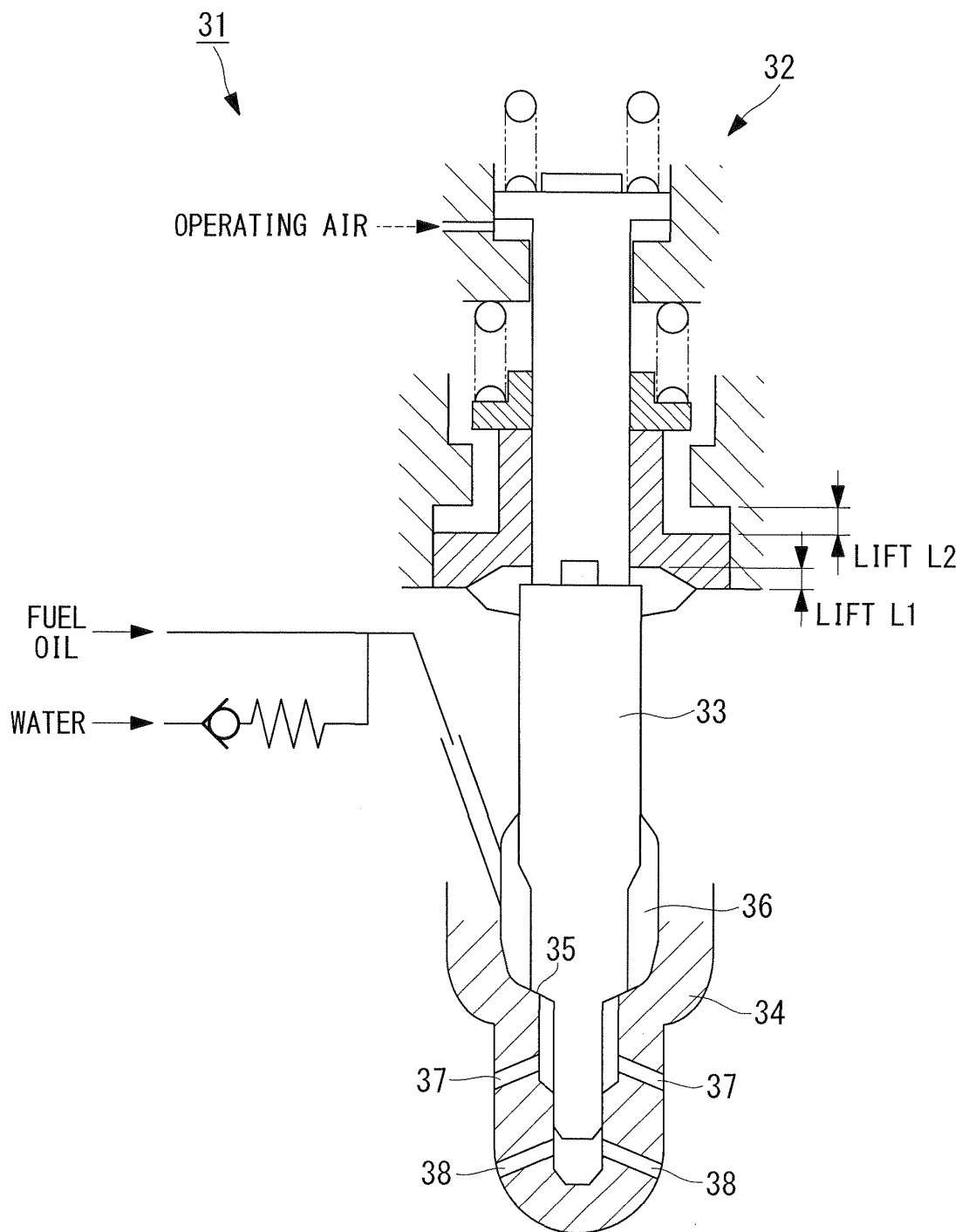


FIG. 5

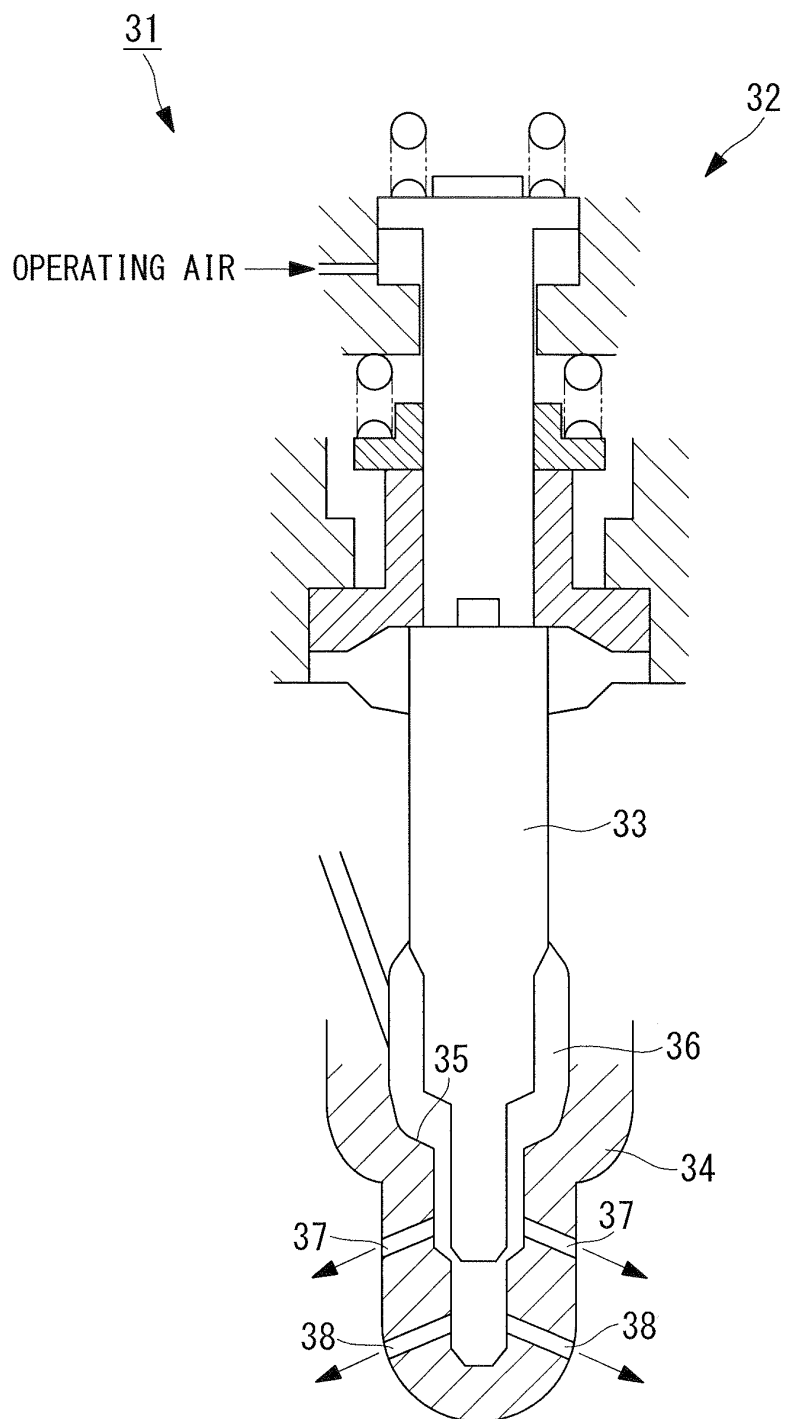


FIG. 6

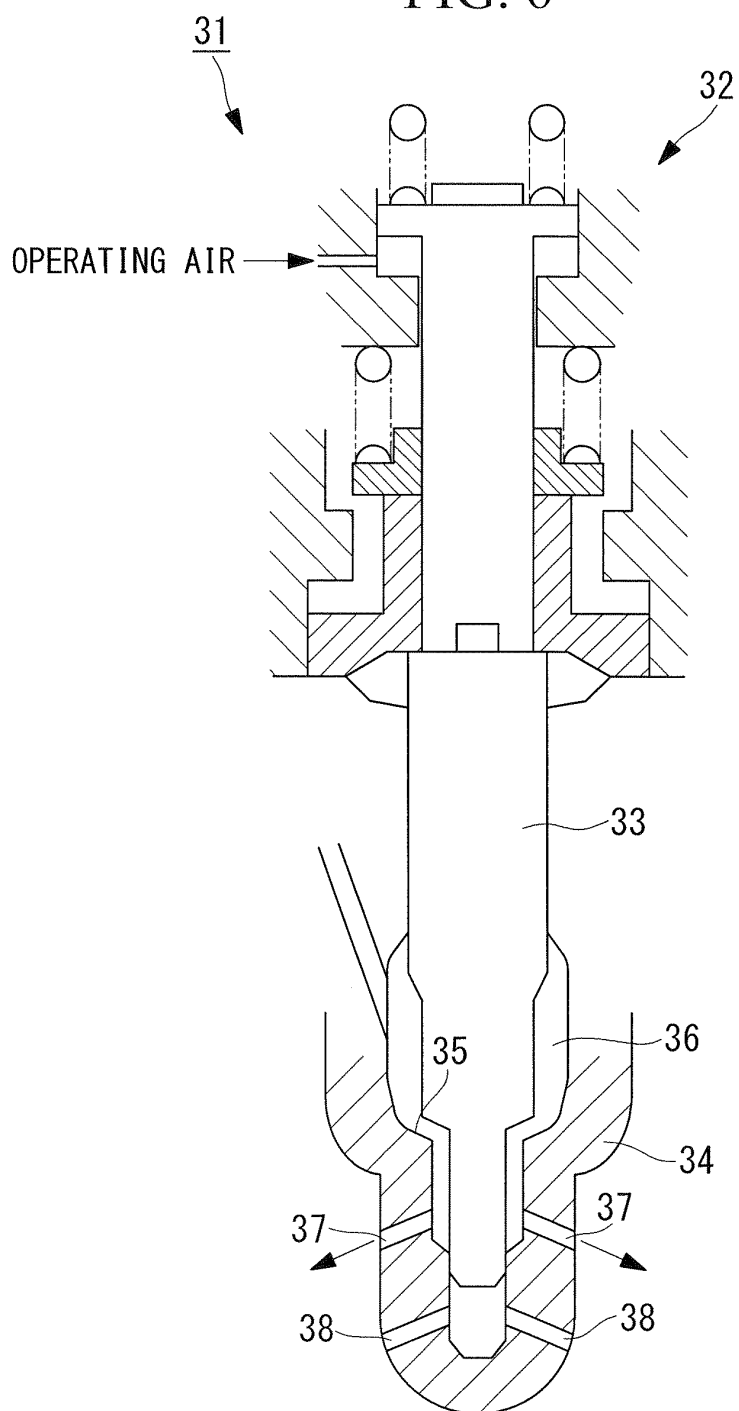


FIG. 7

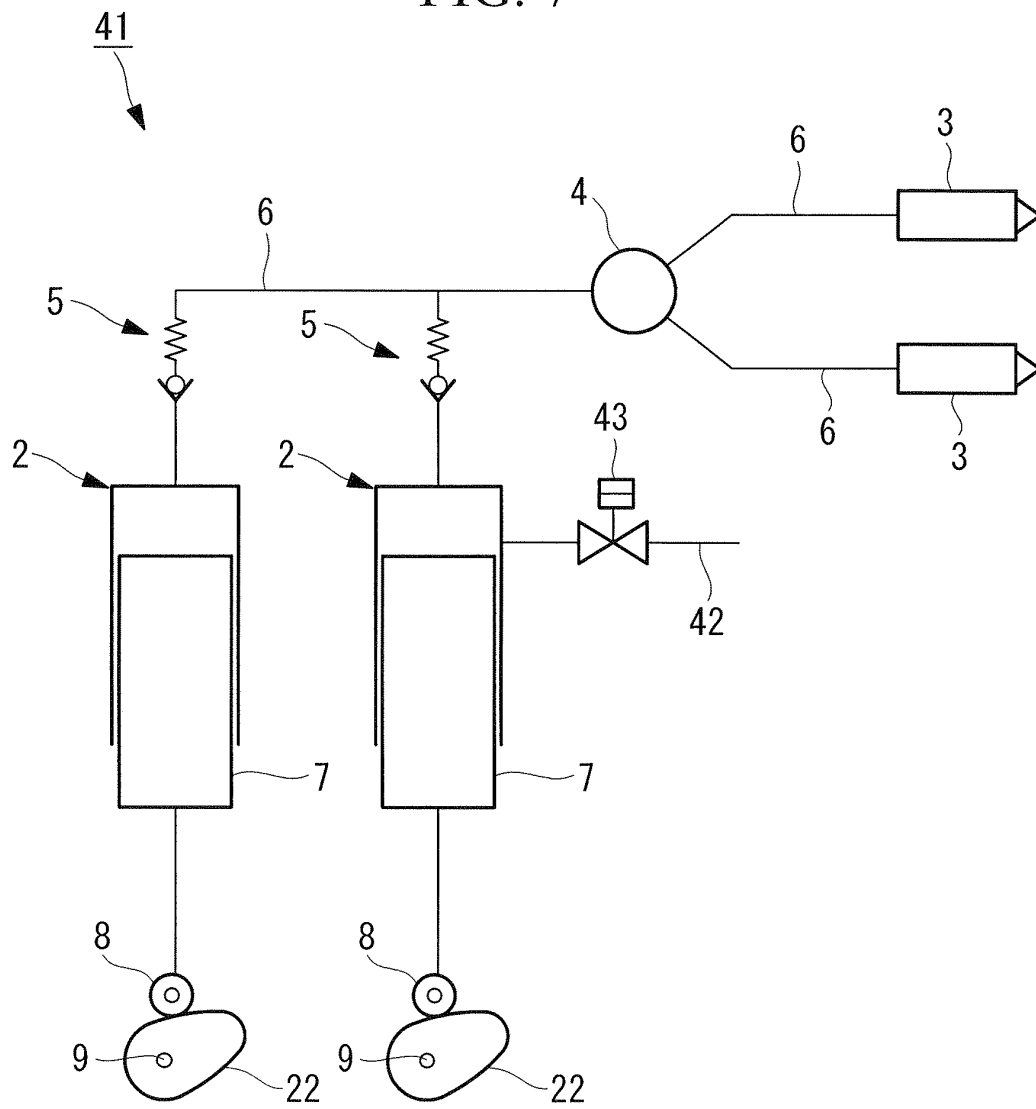


FIG. 8

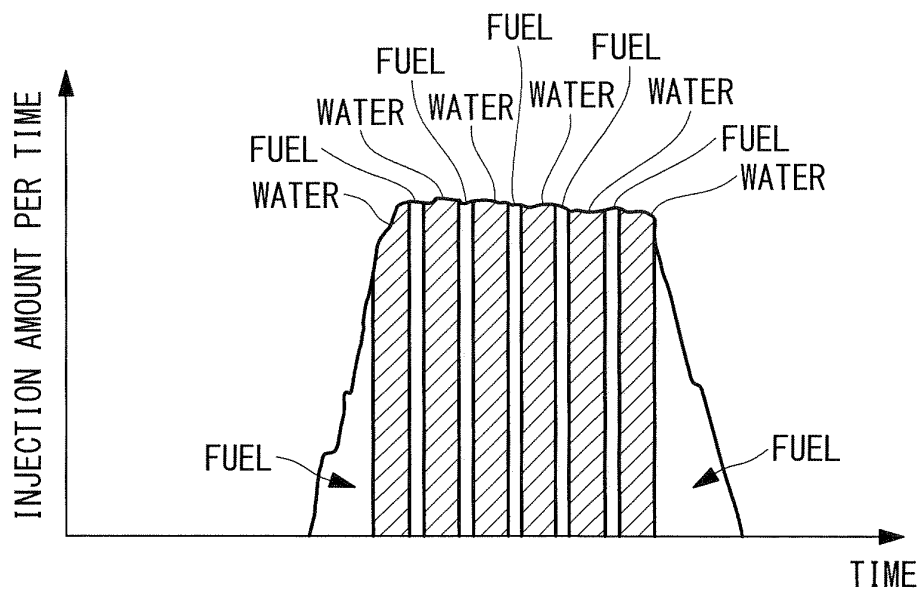
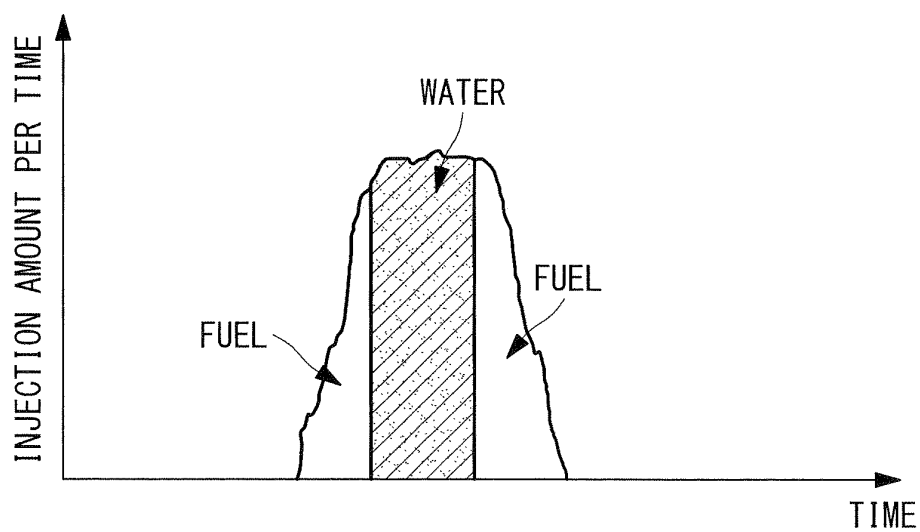


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/075217

A. CLASSIFICATION OF SUBJECT MATTER

F02M25/022(2006.01) i, F02B47/04(2006.01) i, F02M43/02(2006.01) i, F02M43/04(2006.01) i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F02M25/022, F02B47/04, F02M43/02, F02M43/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2012
Kokai Jitsuyo Shinan Koho	1971-2012	Toroku Jitsuyo Shinan Koho	1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2002-202007 A (Mitsubishi Heavy Industries, Ltd.), 19 July 2002 (19.07.2002), paragraphs [0053] to [0061]; fig. 3 (Family: none)	1, 5, 6
Y	JP 08-144883 A (Mitsubishi Motors Corp.), 04 June 1996 (04.06.1996), paragraphs [0039] to [0040]; fig. 1 (Family: none)	3
Y	JP 03-011148 A (Mitsubishi Heavy Industries, Ltd.), 18 January 1991 (18.01.1991), page 1, lower right column, lines 15 to 18 (Family: none)	3

☒ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
24 January, 2012 (24.01.12)Date of mailing of the international search report
07 February, 2012 (07.02.12)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/075217

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 11-030165 A (Mitsubishi Heavy Industries, Ltd.), 02 February 1999 (02.02.1999), paragraphs [0028] to [0032]; fig. 2 (Family: none)	3
A	JP 2001-508522 A (Robert Bosch GmbH), 26 June 2001 (26.06.2001), entire text; all drawings & US 6273032 B1 & EP 954695 A & WO 1999/022133 A1	1-6
A	JP 09-126085 A (Robert Bosch GmbH), 13 May 1997 (13.05.1997), entire text; all drawings & US 5671717 A1 & EP 0760425 A1	1-6
A	JP 06-101590 A (Mitsubishi Heavy Industries, Ltd.), 12 April 1994 (12.04.1994), entire text; all drawings (Family: none)	1-6

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/075217

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

The technical feature common to the inventions of claims 1-6 is "a fuel injection system for an internal combustion engine, which is capable of selectively injecting a multilayer form or emulsion of a fuel oil and an inert substance or a fuel oil only from a fuel injection valve". This technical feature, however, cannot be considered as a special technical feature since it does not make a contribution over the prior art in view of the disclosure of document 1: JP 2002-202007 A (Mitsubishi Heavy Industries, Ltd.), 19 July 2002 (19.07.2002), paragraphs [0053]-[0061], fig. 3. In addition, there is no other same or corresponding special technical feature among those inventions. (Continued to extra sheet)

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (2)) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2011/075217

Continuation of Box No.III of continuation of first sheet (2)

Consequently, the claims of this international application contain four (groups of) inventions.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP HEI0811945 B [0003]
- JP 3615260 B [0003]