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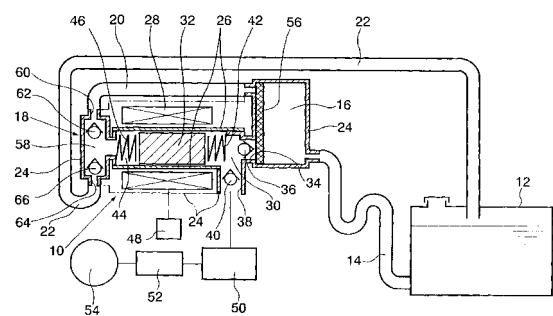
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(54) **FUEL FEED DEVICE**

(57) The object of the present invention is to provide a fuel supply apparatus, with which a fuel tank can be flexibly arranged in the vertical direction, with which the diameter of a fuel introducing passage can be smaller than the conventional fuel introducing passage, and with which the fuel introducing passage can bend in the vertical direction.

Fuel which is introduced from the fuel tank 12 through the fuel introducing passage 14 is transiently stored in the fuel reservoir 16. The lower part of the fuel reservoir 16 and the pump room 30 of the solenoid pump 10 are connected through the inlet valve 36. The upper part of the fuel reservoir 16 and the sub pump 18 are connected through the sub fuel introducing passage 20. The sub pump 18 is connected to the upper part of the fuel tank 12 through the sub fuel eject passage 22. Vapor is accumulated at the upper part of the fuel reservoir 16, and the vapor is returned to the fuel tank 12 through the sub fuel introducing passage 20, sub pump 18, and the sub fuel eject passage 22. With this structure, flexibility in the vertical direction of the fuel tank 12 can be obtained, the diameter of the fuel introducing passage can be small, and the fuel introducing passage can bend in the vertical direction.

FIG. 1



Description

TECHNICAL FIELD

[0001] The present invention relates to a fuel supply apparatus which has a main pump and a sub pump.

BACKGROUND ART

[0002] A fuel supply apparatus with a solenoid pump is well known as a fuel supply system for supplying fuel from a fuel tank to an engine etc. As an example, such a solenoid pump is disclosed in Patent Document 1. The schematic drawing of the fuel supply apparatus with a solenoid pump in Patent Document 1 is shown in Fig. 6. The fuel supply apparatus comprises a solenoid pump 70 and a fuel introducing passage 74 which connects the solenoid pump 70 and a fuel tank 72. A filter 76 is disposed at some midway of the fuel introducing passage 74, and fuel passing through the filter 76 is introduced to the solenoid pump 70.

[0003] The solenoid pump 70 comprises a housing 78, a cylindrical body 80 which is disposed in the housing 78, a coil 82 which is wound around the cylindrical body 80, a plunger 86 which slides and reciprocates in the cylindrical body 80 and in which a passage 84 is formed, a pump room 88 which is formed at one end side of the plunger 86 and is connected to the passage 84, an inlet valve 90 which inlets fuel into the pump room 88, and an outlet valve 92 which outlets the fuel from the pump room 88 out of the solenoid pump 70. On-Off control of the powering to the coil 82 of the solenoid pump 70 is performed by an electronic control circuit 94 which is disposed outside the solenoid pump 70. With the solenoid pump 70, the plunger 86 reciprocates by the On-Off control of the powering to the coil 82, and the inlet valve 90 and the outlet valve 92 are respectively opened and closed so as to inlet and outlet fuel with the pressure change of the pump room 88 which is generated by the reciprocating motion of the plunger 86.

[0004] A pressure regulator 96 and an injector 98 are disposed in the vicinity of the outlet valve 92 side of the solenoid pump 70. The fuel which is discharged from the solenoid pump 70 is injected from the injector 98 towards an engine 99, for example.

[0005] Patent Document 1: Japanese Patent Laid-Open H11-218076, Page 4-5, Fig. 1

[0006] In the solenoid pump 70, fuel is heated by the heat generated at the coil 82 when the coil 82 is powered and the friction heat generated by the sliding of the plunger 86. Then, vapor is continuously generated in the fuel. Further, when the atmospheric temperature around the engine is high, vapor is generated in the fuel in the fuel introducing passage 74 and the solenoid pump 70. When the fuel containing vapor is injected from the injector 98 to the engine 99, the desired amount of fuel cannot be obtained. Therefore, there occurs a problem that the driving performance becomes unstable.

[0007] With the fuel supply apparatus having the solenoid pump 70, measures are taken to eliminate the vapor generated at the solenoid pump 70 as follows. First, the fuel tank 72 is disposed above the solenoid pump 70. Second, the fuel introducing passage 74 which connects the fuel tank 72 and the solenoid pump 70 is set so as not to have a vertical bend, namely, not to form a mountain or a valley, at any midway. Third, the diameter of the fuel introducing passage 74 is set to the size in which fuel and vapor simultaneously flow in the opposite direction, namely the diameter is equal to or larger than 8 mm.

[0008] By taking these three measures, even when vapor is generated in the solenoid pump 70, vapor can return to the fuel tank 72 rising by itself through the fuel introducing passage 74.

DISCLOSURE OF THE INVENTION

Problems to be solved by the invention

[0009] With the abovementioned fuel supply apparatus, since the vapor generated at the solenoid pump 70 returns to the fuel tank 72 rising by itself through the fuel introducing passage 74, the fuel tank 72 must be disposed above the solenoid pump 70. Therefore, there is a restriction on the flexibility of vertical arrangement of the fuel tank 72 and the solenoid pump 70, particularly, that the fuel tank 72 cannot be disposed below the solenoid pump 70 etc.

[0010] Further, the diameter of the fuel introducing passage 74 must be equal to or larger than 8 mm in order for the vapor to return by itself through the fuel introducing passage 74. Therefore, there is a problem that the outside diameter of the introducing piping (not shown in drawings) in which the fuel introducing passage 74 is disposed becomes large. Furthermore, when the fuel introducing passage 74 is formed to have a mountain or a valley vertically at some midway, there is a possibility that the vapor may stay at the midway and the desired amount of fuel cannot be supplied to the solenoid pump 70 from the fuel tank 72. Therefore, a mountain or a valley must not be formed vertically at some midway of the fuel introducing passage 74.

[0011] The present invention was devised in view of the abovementioned points. The object of the present invention is to provide a fuel supply apparatus, with which a fuel tank can be flexibly arranged in the vertical direction, with which the diameter of a fuel introducing passage can be smaller than the conventional apparatus, and with which the fuel introducing passage can bend in the vertical direction.

Means to solve the problems

[0012] A fuel supply apparatus of the present invention comprises a main pump having a housing and a pump room formed in the housing, a first operating means for operating the main pump, a fuel introducing passage for

introducing fuel from a fuel tank to the main pump, a fuel reservoir connected to the fuel introducing passage and to the pump room, a sub pump having a sub pump room and disposed at the downstream side than the fuel reservoir, a second operating means for operating the sub pump, a sub fuel introducing passage to connect the sub pump room and the fuel reservoir, and a sub fuel eject passage to connect the sub pump room and the fuel tank, and the connecting position of the fuel reservoir to the sub fuel introducing passage is higher than the connecting position of the fuel reservoir to the pump room.

[0013] In the fuel supply apparatus of the present invention, the main pump comprises an inlet valve to allow fuel sucking to the pump room and an outlet valve to allow fuel discharging from the pump room. In the fuel supply apparatus of the present invention, the sub pump comprises an inlet valve to allow fuel sucking to the sub pump room and an outlet valve to allow fuel discharging from the sub pump room. In the fuel supply apparatus of the present invention, the fuel reservoir is disposed in the housing of the main pump. In the fuel supply apparatus of the present invention, the sub pump is disposed in the housing of the main pump. In the fuel supply apparatus of the present invention, at least one filter is disposed at both connecting positions in the fuel reservoir to the sub fuel eject passage and to the pump room. In the fuel supply apparatus of the present invention, the sub fuel eject passage is connected to the upper part of the fuel tank. In the fuel supply apparatus of the present invention, the first operating means comprises a coil, and a plunger which defines the pump room and changes the pressure in the pump room by reciprocating with the electromagnetic force of the coil. In the fuel supply apparatus of the present invention, the second operating means comprises the coil, and the plunger which defines the sub pump room and changes the pressure in the sub pump room by reciprocating with the electromagnetic force of the coil. In the fuel supply apparatus of the present invention, the first operating means comprises a diaphragm which defines the pump room and changes the pressure in the pump room with pulse pressure of an internal combustion engine. In the fuel supply apparatus of the present invention, the second operating means comprises the diaphragm which moves with pulse pressure of an internal combustion engine, and a membrane which moves in accordance with the movement of the diaphragm and changes pressure in the sub pump room.

Effects of the invention

[0014] With the present invention, fuel is introduced from a fuel tank to a fuel reservoir through a fuel introducing passage by the pressure drop in the fuel reservoir. In this manner, the position of the fuel tank against the position of a main pump is not restricted in the vertical direction. Then, the flexibility of the vertical position of the fuel tank can be obtained. With this structure, the fuel tank can be disposed under the foot of a scooter, which

has not been possible. Further, the fuel and vapor flow in the same direction in the fuel introducing passage from the fuel tank towards the fuel reservoir, namely, the vapor does not flow towards the fuel tank side. Therefore, the diameter of the fuel introducing passage can be small, and the fuel introducing passage can be formed to have a mountain or a valley at some midway. As a result, a commonly used hose can be adopted as the piping of the fuel introducing passage, and the flexibility of the piping arrangement can be greatly improved. Moreover, cost reduction can be achieved.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a partially sectioned schematic drawing showing an embodiment of a fuel supply apparatus of the present invention.

Fig. 2 is a schematic drawing showing the flow of fuel and vapor in the state that the solenoid is powered.

Fig. 3 is a schematic drawing showing the flow of fuel and vapor in the state that the solenoid is not powered.

Fig. 4 is a pulse signal diagram of the powering to the solenoid.

Fig. 5 is a partially sectioned schematic drawing showing another embodiment of the fuel supply apparatus of the present invention.

Fig. 6 is a schematic drawing showing a conventional fuel supply apparatus which has a solenoid pump.

EXPLANATION OF NUMERALS

[0016]

10	solenoid pump
12	fuel tank
14	fuel introducing passage
16	fuel reservoir
18	sub pump
20	sub fuel introducing passage
22	sub fuel return passage
24	housing
26	cylindrical body
28	coil
30	pump room
32	plunger
34	inlet port
36	inlet valve
38	outlet port
40	outlet valve
44	rear pressure room
56	filter
58	sub pump room
60	inlet port
62	sub inlet valve

64 outlet port
 66 sub outlet valve
 100 diaphragm pump
 108 inlet valve
 110 outlet valve
 116 diaphragm
 118 membrane
 120 pump room
 122 pulse room
 124 pulse introducing passage
 126 fuel inlet room
 128 fuel outlet room
 130 damper room
 132 rear pressure room

BEST MODE FOR CARRYING OUT THE INVENTION

[0017] With the present invention, fuel from the fuel tank is transiently stored in the fuel reservoir. Then, fuel is introduced to the main pump from the lower side of the fuel reservoir so as to prevent the introduction of vapor to the main pump. On the contrary, fuel containing vapor is introduced to the sub pump from the upper side of the fuel reservoir so as to return the vapor along with the fuel from the sub pump to the fuel tank.

[The first embodiment]

[0018] Next, the present invention is explained based on the drawings. Fig. 1 is a partially sectioned schematic drawing showing an embodiment of a fuel supply apparatus of the present invention. The fuel supply apparatus of the present invention comprises a solenoid pump 10 as the main pump to suck and discharge fuel, a fuel introducing passage 14 to introduce fuel from a fuel tank 12 to the solenoid pump 10, a fuel reservoir 16 which is disposed between the fuel introducing passage 14 and the solenoid pump 10, a sub pump 18 which operates by utilizing rear pressure of the later-mentioned plunger of the solenoid pump 10, a sub fuel introducing passage 20 to connect the sub pump 18 and the fuel reservoir 16, and a sub fuel return passage 22 to connect the sub pump 18 and the fuel tank 12.

[0019] Fuel in the fuel tank 12 is introduced to the fuel reservoir 16 through the fuel introducing passage 14, and the fuel is stored in the fuel reservoir 16 transiently. The connecting position of the fuel introducing passage 14 to the fuel tank 12 is the lower part of the fuel tank 12, which is below the fuel level. Although the connecting position of the fuel introducing passage 14 to the fuel reservoir 16 is not specifically restricted, the lower part of the fuel reservoir 16 is preferred.

[0020] The solenoid pump 10 comprises a housing 24, a cylindrical body 26 which is disposed in the housing 24, a coil 28 which is disposed outside the cylindrical body 26, a pump room 30 which is formed in the housing 24, a solid and cylindrical plunger 32 which defines the pump room 30 and reciprocates in the cylindrical body 26 by

the electromagnetic force of a coil 28, an inlet valve 36 which is disposed at the vicinity of an inlet port 34 of the pump room 30 to allow the fuel to be sucked to the pump room 30, an outlet valve 40 which is disposed at the vicinity of an outlet port 38 of the pump room 30 to allow the fuel to be discharged from the pump room 30, a first return spring 42 which urges the plunger 32 in the direction being apart from the pump room 30, a rear pressure room 44 which is formed at the opposite side of the plunger 32 to the pump room 30, and a second return spring 46 which is disposed in the rear pressure room 44 and urges the plunger 32 towards the pump room 30 side. On-Off control of the powering to the coil 28 of the solenoid pump 10 is performed by an electronic control circuit 48. The discharged fuel from the solenoid pump 10 flows to an injector 52 etc. through a pressure regulator 50, and is injected from the injector 52 towards an engine 54 etc.

[0021] The fuel reservoir 16 is connected to the inlet port 34 of the pump room 30 of the solenoid pump 10, and the inlet port 34 is opened and closed by the inlet valve 36. The inlet valve 36 which is disposed at the inlet port 34 of the pump room 30 of the solenoid pump 10 opens the inlet port 34 to introduce fuel from the fuel reservoir 16 to the pump room 30 when the fuel pressure in the pump room 30 becomes lower than the fuel pressure in the fuel reservoir 16 by a specific amount. The outlet valve 40 which is disposed at the outlet port 38 of the pump room 30 opens the outlet port 38 to discharge fuel from the pump room 30 towards the pressure regulator 50 when the fuel pressure in the pump room 30 becomes equal to or higher than a specific pressure. A first operating means, which operates the inlet valve 36 and the outlet valve 40 by changing the pressure in the pump room 30, comprises the coil 28 and the plunger 32 which is reciprocated by the electromagnetic force of the coil 28.

[0022] In the fuel reservoir 16, a filter 56 is disposed at the connecting position to the inlet port 34 of the pump room 30. The filter 56 does not have to be disposed in the fuel reservoir 16 and can also be disposed either in the fuel introducing passage 14 or in the fuel tank 12. As shown in Fig. 1, the fuel reservoir 16 is preferred to be formed inside the housing 24 of the solenoid pump 10. With this structure, the solenoid pump 10 and the fuel reservoir 16 are integrated, and the fuel supply apparatus of the present invention can be formed compactly. Here, it is also possible to arrange the fuel reservoir 16 separately from the solenoid pump 10.

[0023] The sub pump 18 comprises a sub pump room 58 which is connected to the rear pressure room 44 of the solenoid pump 10, a sub inlet valve 62 which is disposed at the vicinity of an inlet port 60 of the sub pump room 58 to allow the sucking of fuel to the sub pump room 58, and a sub outlet valve 66 which is disposed at the vicinity of an outlet port 64 of the sub pump room 58 to allow the discharging of fuel from the sub pump room 58. Instead of arranging the rear pressure room 44 and the

sub pump room 58 separately, it is possible for the rear pressure room 44 to also work as the sub pump room 58. As shown in Fig. 1, it is preferred that the sub pump 18 is disposed in the housing 24 of the solenoid pump 10. With this structure, the solenoid pump 10 and the sub pump 18 are integrated, and the fuel supply apparatus of the present invention can be formed compactly. Here, it is also possible to arrange the sub pump 18 separately from the solenoid pump 10. A second operating means, which operates the sub inlet valve 62 and the sub outlet valve 66 by changing the pressure in the sub pump room 58, comprises the coil 28 and the plunger 32 which is reciprocated by the electromagnetic force of the coil 28.

[0024] In the sub pump 18, the inlet port 60 of the sub pump room 58 is connected to the fuel reservoir 16 through the sub fuel introducing passage 20. In Fig. 1, the sub fuel introducing passage 20 is shown as being disposed outside the housing 24 of the solenoid pump 10. However, it is also possible to dispose the fuel introducing passage 20 inside the housing 24 of the solenoid pump 10. The outlet port 64 of the sub pump room 58 is connected to the upper part of the fuel tank 12 through the sub fuel return passage 22, which is above the fuel level.

[0025] In the fuel reservoir 16, the sub fuel introducing passage 20 is connected at the upper part, and the inlet port 34 of the pump room 30 of the solenoid pump 10 is connected at the lower part. Further, the filter 56 which is disposed in the fuel reservoir 16 at the connecting position to the inlet port 34 of the pump room 30 is preferred to be as the size that can also be disposed at the connecting position to the sub fuel introducing passage 20. In this manner, both connecting positions to the inlet port 34 of the pump room 30 and to the sub fuel introducing passage 20 are covered with one filter 56. Therefore, the efficiency of the filter attaching process and the efficiency of part management can be improved. Here, it is also possible to arrange the filter which is disposed at the connecting position of the fuel reservoir 16 and the sub fuel introducing passage 20 separately from the filter which is disposed at the connecting position of the fuel reservoir 16 and the inlet port 34 of the pump room 30.

[0026] The sub inlet valve 62 which is disposed at the inlet port 60 of the sub pump room 58 opens the inlet port 60 to introduce fuel and vapor from the fuel reservoir 16 (the sub fuel introducing passage 20) to the sub pump room 58 when the fuel pressure in the sub pump room 58 becomes lower than the fuel pressure in the fuel reservoir 16 (the sub fuel introducing passage 20) by a specific amount. The sub outlet valve 66 which is disposed at the outlet port 64 of the sub pump room 58 opens the outlet port 64 to return fuel and vapor from the sub pump room 58 to the fuel tank 12 through the sub fuel return passage 22 when the fuel pressure in the sub pump room 58 becomes equal to or larger than a specific pressure.

[0027] Next, the flow of fuel and vapor in the fuel supply apparatus of the present invention is explained based on Fig. 2 and Fig. 3. Fig. 2 shows the flow of fuel and vapor

in the state that the coil 28 is powered. Fig. 3 shows the flow of fuel and vapor in the state that the coil 28 is not powered. As shown in Fig. 2, in the state that the coil 28 is powered, the plunger 32 is moved by the electromagnetic force generated at the coil 28 to be apart from the pump room 30 side, namely, towards the rear pressure room 44 side, against the urging force of the second return spring 46. Due to this movement of the plunger 32, the volume of the pump room 30 is increased and the pressure in the pump room 30 is decreased. Then, the inlet valve 36 opens and fuel is introduced from the fuel reservoir 16 into the pump room 30. Due to the decrease of the fuel in the fuel reservoir 16, the pressure in the fuel reservoir 16 is decreased. Then, fuel is introduced from the fuel tank 12 to the fuel reservoir 16 through the fuel introducing passage 14.

[0028] On the other hand, due to the movement of the plunger 32, the volume of the rear pressure room 44 is decreased and the pressure in the rear pressure room 44 is increased. Then, the high pressure in the rear pressure room 44 is transmitted to the sub pump room 58. As a result, the sub outlet valve 66 which is disposed at the outlet port 64 of the sub pump room 58 opens. Then, fuel including vapor in the sub pump room 58 is returned to the fuel tank 12 through the sub fuel return passage 22.

[0029] In the following, it is assumed that the fuel supply apparatus of the present invention is exposed to high atmospheric temperature, and vapor is generated in the remaining fuel in the passage where fuel flows through. When vapor is generated in the fuel in the fuel introducing passage 14 or the fuel in the fuel reservoir 16, the vapor moves to and accumulates at the upper side in the fuel reservoir 16. Since the connecting position to the inlet port 34 of the pump room 30 at the fuel reservoir 16 is located at the lower position of the fuel reservoir 16, vapor is not included in the fuel which is introduced from the fuel reservoir 16 to the pump room 30 of the solenoid pump 10. On the other hand, even when vapor is generated in the fuel in the rear pressure room 44 or in the sub pump room 58, the fuel including vapor is returned from the sub pump room 58 to the fuel tank 12 through the sub fuel return passage 22. Further, even when vapor is generated in the fuel in the sub fuel introducing passage 20 which is disposed between the fuel reservoir 16 and the sub pump room 58, the vapor stays in the sub fuel introducing passage 20 or moves to the fuel reservoir 16. As mentioned above, in the powered state as shown in Fig. 2, the fuel and vapor in the sub pump room 58 is returned to the fuel tank 12 through the sub fuel return passage 22 even when the fuel supply apparatus of the present invention is exposed to high atmospheric temperature. As a result, vapor is not included in the fuel which is introduced to the pump room 30.

[0030] As shown in Fig. 3, in the state that the coil 28 is not powered, the plunger 32 is moved by the urging force of the second return spring 46 towards the pump room 30 side, namely, to be apart from the rear pressure room 44, since the electromagnetic force at the coil 28

disappears. Due to this movement of the plunger 32, the volume of the pump room 30 is decreased and the pressure in the pump room 30 is increased. Then, the outlet valve 40 opens and fuel in the pump room 30 is discharged to the injector 52 through the pressure regulator 50. The fuel is injected from the injector 52 to the engine 54 etc. Here, as mentioned above, vapor is not included in the fuel which is introduced to the pump room 30. Moreover, since the fuel pressure in the passage from the pump room 30 to the injector 52 is high, 300kPa for example, it is considered that there is no vapor in the passage to the injector 52. Therefore, the appropriate amount of fuel can be injected.

[0031] On the other hand, due to the movement of the plunger 32, the volume of the rear pressure room 44 is increased and the pressure in both the rear pressure room 44 and the sub pump room 58 is decreased. As a result, the sub inlet valve 62 of the sub pump room 58 opens. Then, fuel and vapor in the sub fuel introducing passage 20 is introduced to the sub pump room 58. Accordingly, fuel and vapor in the upper part of the fuel reservoir 16 is introduced to the sub fuel introducing passage 20. There is a case that a part of the fuel and vapor in the upper part of the fuel reservoir 16 is included in the fuel and vapor which are introduced to the sub pump room 58 at one intake in addition to all the fuel and vapor in the sub fuel introducing passage 20.

[0032] As shown in Fig. 2 and Fig. 3, the fuel to be discharged from the solenoid pump 10 is transiently stored in the fuel reservoir 16 from the fuel tank 12 through the fuel introducing passage 14. The vapor generated in the fuel reservoir 16 and the fuel introducing passage 14, which is the upstream side thereof, accumulates by itself to the upper position of the fuel reservoir 16 which is the vicinity of the connecting position with the sub fuel introducing passage 20. Since vapor moves upwards by itself, fuel in the lower part of the fuel reservoir 16 does not include any vapor. Since the fuel in the lower part of the fuel reservoir 16 is introduced to the pump room 30 of the solenoid pump 10, the fuel which is discharged from the solenoid pump 10 to the injector 52 does not include any vapor.

[0033] Due to the function of the sub pump 18, the vapor which is accumulated in the upper part of the fuel reservoir 16 is introduced to the sub pump room 58, and then, returned to the fuel tank 12 through the sub fuel return passage 22. When the atmospheric temperature is high, there is a case that vapor is generated in the fuel in the sub fuel introducing passage 20 and in the sub pump room 58. However, the vapor is also returned to the fuel tank 12 from the sub pump room 58 through the sub fuel return passage 22. As mentioned above, with the present invention, vapor is separated from fuel at the fuel reservoir 16. Then, the vapor which is accumulated in the upper part of the fuel reservoir 16 is returned to the fuel tank 12 through an alternative passage which is different from the passage of the pump room 30 of the solenoid pump 10, namely, vapor is returned through the

sub fuel introducing passage 20 and the sub pump room 58 and the sub fuel return passage 22. On the contrary, fuel which is separated at the fuel reservoir 16 so as not to include any vapor is introduced to the pump room 30 of the solenoid pump 10. Therefore, vapor is not included in the fuel which is discharged from the solenoid pump 10, and the desired amount of fuel can be injected.

[0034] With the present invention, fuel is transiently stored in the fuel reservoir 16 from the fuel tank 12 through the fuel introducing passage 14. When the inlet valve 36 of the solenoid pump 10 opens or the sub inlet valve 62 of the sub pump 18 opens, fuel or fuel including vapor is discharged from the fuel reservoir 16. Due to the pressure drop in the fuel reservoir 16, fuel is introduced from the fuel tank 12 to the fuel reservoir 16 through the fuel introducing passage 14. In this manner, since fuel is sucked from the fuel introducing passage 14 by the pressure drop in the fuel reservoir 16, the fuel tank 12 can be disposed below the solenoid pump 10. That is, the fuel tank 12 can be disposed at any height. For example, the fuel tank 12 can be disposed under the foot of a scooter, which has not been possible.

[0035] With the fuel introducing passage for a conventional fuel supply apparatus, vapor is returned from the solenoid pump side towards the fuel tank side while fuel is introduced from the fuel tank side towards the solenoid pump side. Therefore, the diameter of the fuel introducing passage must be equal to or larger than 8mm. On the contrary, in the fuel introducing passage 14 of the present invention, fuel or fuel including vapor flows only in one direction, that is, from the fuel tank 12 side towards the fuel reservoir 16 side (the solenoid pump 10 side). In this manner, even when vapor is generated in the fuel in the fuel introducing passage 14, both fuel and vapor flow in the same direction. Therefore, the diameter of the fuel introducing passage 14 can be greatly reduced than the conventional fuel introducing passage. Further, since fuel is sucked from the fuel introducing passage 14 by the pressure drop in the fuel reservoir 16, fuel can be introduced to the fuel reservoir 16 even when the fuel introducing passage 14 is formed to have a mountain or a valley at some midway. As mentioned above, with the present invention, the diameter of the fuel introducing passage 14 can be smaller than before, and can be formed to have a mountain or a valley at some midway. Therefore, the flexibility of the piping position of the fuel introducing passage 14 is greatly improved. Further, a commonly used hose can be adopted as the piping of the fuel introducing passage 14, and the piping cost of the fuel introducing passage 14 can be reduced.

[0036] With the fuel supply apparatus of the present invention, fuel is sucked into the fuel reservoir 16 twice with one reciprocating motion of the plunger 32. Namely, fuel is sucked into the fuel reservoir 16 in both states that the coil 28 is powered as shown in Fig. 2 and that the coil 28 is not powered as shown in Fig. 3. About twice the amount of fuel is sucked to the fuel reservoir 16 compared to the amount of fuel which is discharged from the

solenoid pump 10. When the remaining fuel is sucked to the sub pump 18, vapor is forced to be sucked to the sub pump 18 along with the fuel. Then, the vapor and the surplus fuel are returned to the fuel tank 12. In this manner, about twice the amount of fuel is introduced to the fuel reservoir 16 compared to the amount of fuel discharged from the solenoid pump 10, and then, vapor is ejected with the surplus fuel when the surplus fuel is returned to the fuel tank 12. Therefore, it is possible not to suck vapor to the pump room 30 of the solenoid pump 10.

[0037] At high temperature, vapor is apt to be generated in the rear pressure room 44. For example, when the stroke of the plunger 32 is small, in other words, when the flow rate is small, there is a possibility that the sub pump 18 does not function as a pump and only changes the volume of the vapor. To make the sub pump 18 function appropriately even when vapor exists in the rear pressure room 44, the stroke amount of the plunger 32 should be increased. More specifically, it is effective to enlarge the driving cycle of the solenoid pump 10. As shown in Fig. 4, it is preferred to set the driving cycle equal to or larger than 40 ms.

[The second embodiment]

[0038] Next, another embodiment of the fuel supply apparatus of the present invention is explained in the following based on Fig. 5. In the first embodiment of the fuel supply apparatus shown in Fig. 1, the solenoid pump 10 is adopted as the main pump. In the second embodiment of the fuel supply apparatus, a diaphragm pump 100 is adopted as the main pump instead of the solenoid pump 10. In Fig. 5, the same numeral is given to the same member as in Fig. 1. The diaphragm pump 100 for sucking and discharging fuel comprises a first housing 106 which mainly forms an inlet connect passage 102 and an outlet connect passage 104, an inlet valve 108 which opens and closes the inlet connect passage 102, an outlet valve 110 which opens and closes the outlet connect passage 104, a second housing 112 which is attached to one side face of the first housing 106, a cover 114 which is attached to the other side face of the first housing 106, a diaphragm 116 which is sandwiched by the first housing 106 and the second housing 112, and a membrane 118 which is sandwiched by the first housing 106 and the cover 114.

[0039] A pump room 120 is formed between the diaphragm 116 and the first housing 106, and a pulse room 122 is formed between the diaphragm 116 and the second housing 112. A pulse introducing passage 124 which is connected to the pulse room 122 is formed at the second housing 112, and the pulse pressure which is generated at the engine 54 is introduced to the pulse room 122 through the pulse introducing passage 124.

[0040] A fuel inlet room 126 as the inlet port and a fuel outlet room 128 as the outlet port are formed between the membrane 118 and the first housing 106. The fuel inlet room 126 is connected to the fuel reservoir 16, and

fuel is introduced to the fuel inlet room 126 from the fuel reservoir 16. At the fuel reservoir 16, the connecting position to the fuel inlet room 126 is set to be lower than the connecting position to the sub fuel introducing passage 20. The fuel inlet room 126 is connected to the pump room 120 through the inlet connect passage 102 which has the inlet valve 108. The inlet valve 108 is set to let fuel flow only in the direction from the fuel inlet room 126 towards the pump room 120. The fuel outlet room 128 is connected to the pump room 120 through the outlet connect passage 104 which has the outlet valve 110. The outlet valve 110 is set to let fuel flow only in the direction from the pump room 120 towards the fuel outlet room 128. The fuel outlet room 128 is connected to the injector 52 through the pressure regulator 50, and fuel is discharged from the fuel outlet room 128 towards the injector 52.

[0041] A damper room 130 which faces the fuel inlet room 126 sandwiching the membrane 118 and a rear pressure room 132 which faces the fuel outlet room 128 sandwiching the membrane 118 are formed between the membrane 118 and the cover 114. The rear pressure room 132 is connected to the sub pump room 58 of the sub pump 18. Therefore, the rear pressure room 132 can also be regarded as the sub pump room 58.

[0042] With this diaphragm pump 100, the pulse pressure generated at a crankcase (not shown in drawings) of an engine is introduced to the pulse room 122. Due to the pulse pressure which is introduced to the pulse room 122, the diaphragm 116 reciprocates alternately to the pump room 120 side and the pulse room 122 side. Due to this movement of the diaphragm 116 towards the pulse room 122, fuel is introduced from the fuel inlet room 126 to the pump room 120. Accordingly, fuel is introduced from the fuel reservoir 16 to the fuel inlet room 126. Next, due to the movement of the diaphragm 116 towards the pump room 120 side, fuel is discharged from the pump room 120 to the fuel outlet room 128, and fuel is discharged from the fuel outlet room 128 towards the injector 52. The first operating means, which operates the inlet valve 108 and the outlet valve 110 by changing the pressure in the pump room 120 utilizing pulse pressure of an internal combustion engine, comprises the diaphragm 116 which defines the pump room 120.

[0043] When fuel is discharged from the pump room 120 to the fuel outlet room 128, the membrane 118 moves to the rear pressure room 132 side. Then, the volume of the rear pressure room 132 is decreased, and the pressure in the rear pressure room 132 is increased. The increased pressure is transmitted to the sub pump room 58 of the sub pump 18. The increased pressure opens the sub outlet valve 66, and fuel is returned from the sub pump 18 to the fuel tank 12 through the fuel return passage 22. When the discharging of the fuel from the fuel outlet room 128 is accomplished, the membrane 118 moves to the fuel outlet room 128 side. Then, the pressure in the rear pressure room 132 is decreased, and the decreased pressure is transmitted to the sub pump room

58 of the sub pump 18. The decreased pressure opens the sub inlet valve 62, and fuel is introduced from the fuel reservoir 16 to the sub pump 18 through the sub fuel introducing passage 20. The second operating means, which operates the sub inlet valve 62 and the sub outlet valve 66 by changing the pressure in the sub pump room 58, comprises the diaphragm 116 which is moved by the pulse pressure of an internal combustion engine and the membrane 118 which is moved in accordance with the movement of the diaphragm 116.

[0044] The fuel sucking and discharging operation of the pump room 120 of the diaphragm pump 100 of the second embodiment is the same as that of the pump room 30 of the solenoid pump 10 of the first embodiment. Further, the effect of the fuel pressure change from the diaphragm pump 100 towards the sub pump room 58 of the second embodiment is the same as the effect of the fuel pressure change from the solenoid pump 10 towards the sub pump room 58 of the first embodiment. Therefore, the fuel supply apparatus of the second embodiment has the same effects of that of the first embodiment.

Claims

1. A fuel supply apparatus, comprising:

a main pump having a housing and a pump room formed in said housing;
 a first operating means for operating said main pump;
 a fuel introducing passage for introducing fuel from a fuel tank to said main pump;
 a fuel reservoir connected to said fuel introducing passage and to said pump room;
 a sub pump having a sub pump room and disposed at the downstream side than said fuel reservoir;
 a second operating means for operating said sub pump;
 a sub fuel introducing passage to connect said sub pump room and said fuel reservoir; and
 a sub fuel eject passage to connect said sub pump room and said fuel tank;
 wherein the connecting position of said fuel reservoir to said sub fuel introducing passage is higher than the connecting position of said fuel reservoir to said pump room.

2. The fuel supply apparatus according to claim 1, wherein said main pump comprises an inlet valve to allow fuel sucking to said pump room and an outlet valve to allow fuel discharging from said pump room.

3. The fuel supply apparatus according to claim 1, wherein said sub pump comprises an inlet valve to allow fuel sucking to said sub pump room and an outlet valve to allow fuel discharging from said sub

pump room.

4. The fuel supply apparatus according to claim 1, wherein said fuel reservoir is disposed in said housing of said main pump.

5. The fuel supply apparatus according to claim 1, wherein said sub pump is disposed in said housing of said main pump.

6. The fuel supply apparatus according to claim 1, wherein at least one filter is disposed at both connecting positions in said fuel reservoir to said sub fuel eject passage and to said pump room.

7. The fuel supply apparatus according to claim 1, wherein said sub fuel eject passage is connected to the upper part of said fuel tank.

8. The fuel supply apparatus according to claim 1, wherein said first operating means comprises a coil, and a plunger which defines said pump room and changes the pressure in said pump room by reciprocating with the electromagnetic force of said coil.

9. The fuel supply apparatus according to claim 8, wherein said second operating means comprises said coil, and said plunger which defines said sub pump room and changes pressure in said sub pump room by reciprocating with the electromagnetic force of said coil.

10. The fuel supply apparatus according to claim 1, wherein said first operating means comprises a diaphragm which defines said pump room and changes the pressure in said pump room with pulse pressure of an internal combustion engine.

11. The fuel supply apparatus according to claim 10, wherein said second operating means comprises said diaphragm which moves with pulse pressure of an internal combustion engine, and a membrane which moves in accordance with the movement of said diaphragm and changes pressure in said sub pump room.

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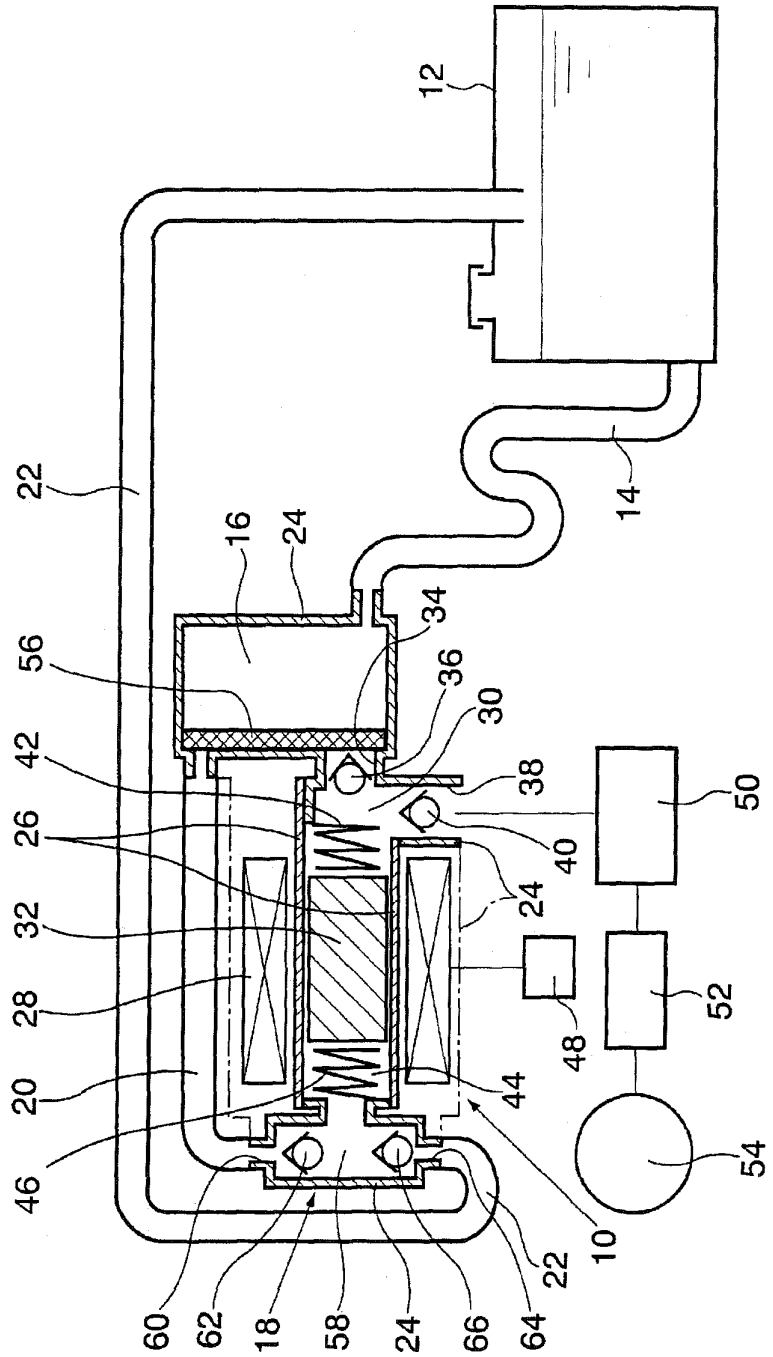


FIG.2

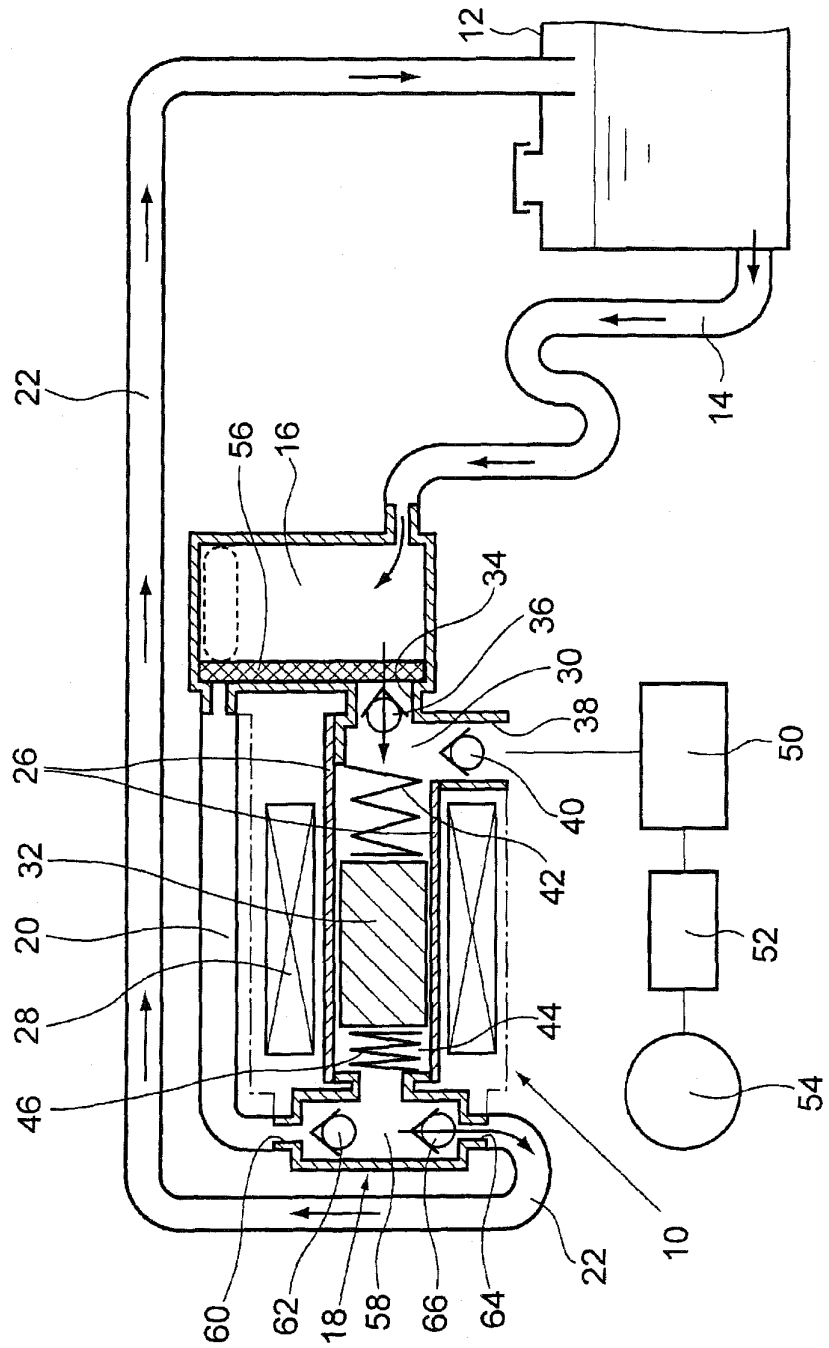


FIG.3

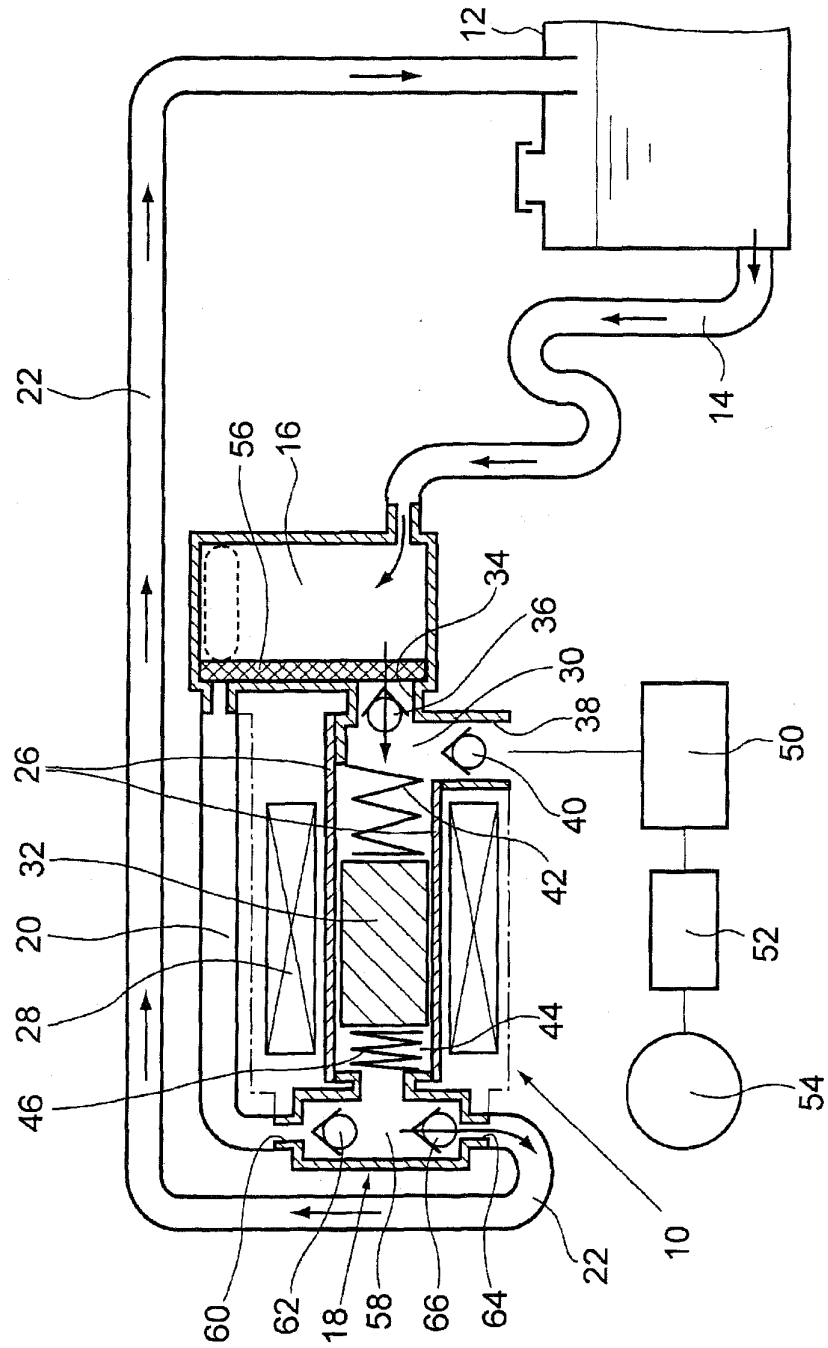
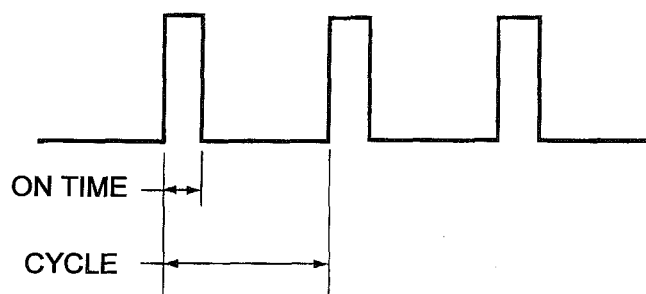


FIG.4



LG

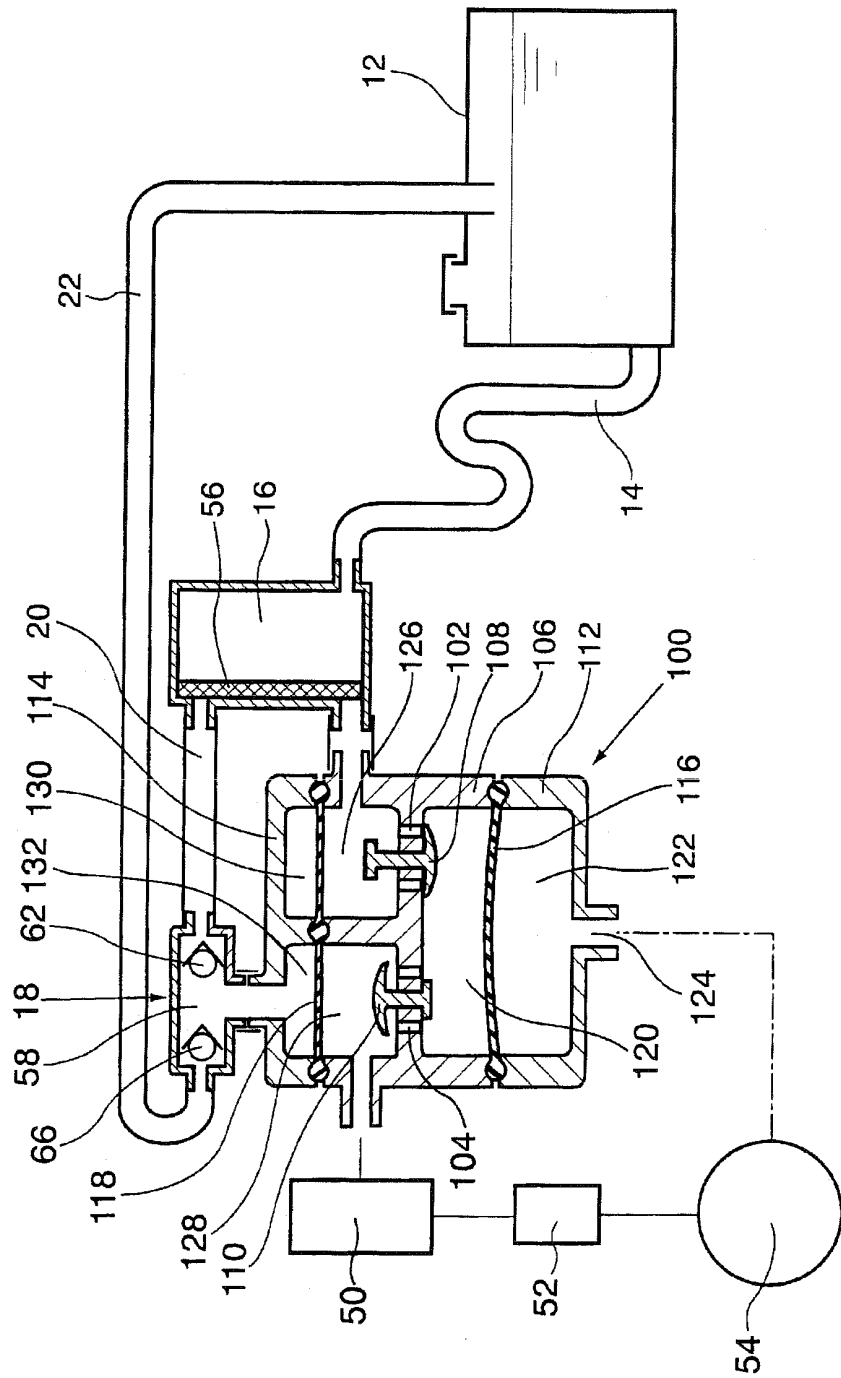
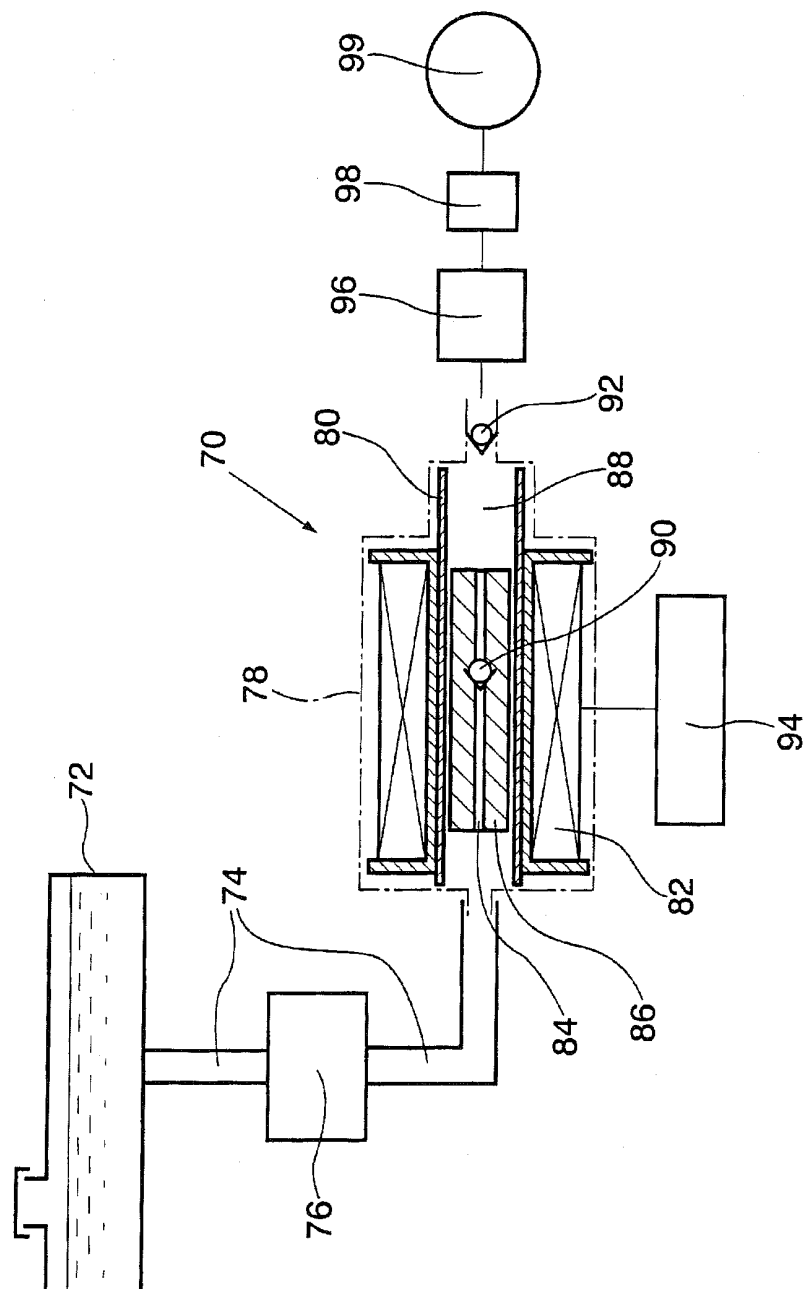


FIG. 6



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/012651

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. ⁷ F02M37/20, 25/08, 37/00, 37/06		
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) Int.Cl. ⁷ F02M37/20, 25/08, 37/00, 37/06		
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 1996-2005 Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005		
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.
Y	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 71075/1991 (Laid-open No. 17157/1993) (Kubota Corp.), 05 March, 1993 (05.03.93), Par. Nos. [0007] to [0009]; Figs. 1(B), 5(A) (Family: none)	1-11
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 55286/1989 (Laid-open No. 145657/1990) (Mitsubishi Heavy Industries, Ltd.), 11 December, 1990 (11.12.90), Full text; all drawings (Family: none)	1-11
☒ 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 26 August, 2005 (26.08.05)		Date of mailing of the international search report 13 September, 2005 (13.09.05)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/012651

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 62-26367 A (Sanshin Kogyo Kabushiki Kaisha), 04 February, 1987 (04.02.87), Full text; all drawings (Family: none)	6
Y	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 197137/1983 (Laid-open No. 107360/1985) (Tohoku Mikuni Kogyo Kabushiki Kaisha), 22 July, 1985 (22.07.85), Full text; all drawings (Family: none)	6
Y	JP 2002-195122 A (Mikuni Corp.), 10 July, 2002 (10.07.02), Full text; all drawings (Family: none)	8-9

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP H11218076 A [0005]