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(54) **Apparatus for controlling the temperature of fuel supplied to an engine**

(57) An apparatus (10) for controlling the temperature of fuel supplied to an engine is disclosed. The apparatus comprises a first inlet (20) for receiving fuel from a fuel tank; a second inlet (30) for receiving fuel returned from an engine; a first outlet (40) for passing fuel to an engine and a second outlet (50) for passing fuel to a fuel tank. A valve is also provided for directing fuel received from the second inlet (30) to one or both of the first (40) and second (50) outlets wherein the valve is arranged to

vary the proportion of fuel directed to the first (40) and second (50) outlets. Varying the proportion of relatively hot fuel received from the engine via the second inlet (30) to be returned either to the engine and/or the fuel tank enables the temperature of fuel supplied to the engine to be controlled. The proportion of the fuel received from the second inlet (30) to be returned either to the engine and/or the fuel tank is preferably dependent upon the fuel temperature.

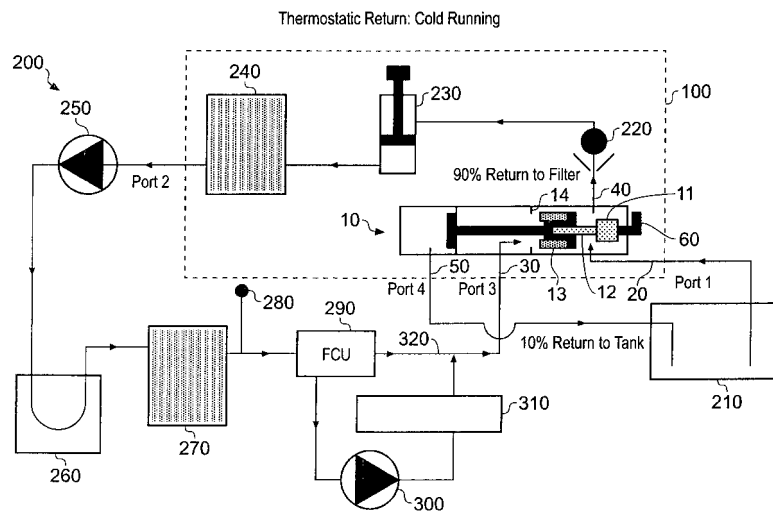


Fig. 2

Description

[0001] The present invention relates to an apparatus for controlling the temperature of fuel supplied to an internal combustion engine such as a diesel engine.

[0002] Maintaining fuel within a suitable temperature range enhances engine performance, especially in cold start conditions. Fuel temperature is generally controlled using electrically powered heaters.

[0003] According to a first aspect of the present invention there is provided an apparatus for controlling the temperature of fuel supplied to an engine, the apparatus comprising:

a first inlet for receiving fuel from a fuel tank;
a second inlet for receiving fuel returned from an engine;
a first outlet for passing fuel to an engine;
a second outlet for passing fuel to a fuel tank and
a valve for directing fuel received from the second inlet to one or both of the first and second outlets wherein the valve is arranged to vary the proportion of fuel directed to the first and second outlets.

[0004] The ability to vary the proportion of relatively hot fuel received from an engine to be directed back to the engine via the first outlet enables the temperature of fuel supplied to an engine to be controlled within limits and thus the engine performance may be enhanced.

[0005] The proportion of fuel directed back to the engine and/or the fuel tank is preferably varied dependent upon fuel temperature. The proportion of fuel directed back to the engine and/or the fuel tank may be varied dependent upon the temperature of the fuel in the apparatus, the temperature of the fuel at the first inlet and/or the temperature of the fluid at the second inlet.

[0006] When the fuel is relatively cold, the valve in the apparatus allows a relatively large amount of relatively hot fuel received from an engine via the second inlet to be directed back to the engine via the first outlet. When the fuel is relatively hot, the valve in the apparatus allows a relatively large amount or all of the relatively hot fuel received from an engine via the second inlet to be directed to a fuel tank via the second outlet. The valve is preferably arranged to gradually vary the proportion of fuel returned from an engine via the second inlet to the first and second outlets.

[0007] The apparatus preferably has a shut off valve arranged to pass all of the fuel received from the engine via the second inlet to the fuel tank via the second outlet regardless of the position of the variable valve. The shut off valve may be manually actuatable. The shut off valve ensures that air from the fuel system during a priming phase is directed back to a fuel tank and not back to an engine resulting in the permanent recirculation of air. The apparatus is preferably arranged such that the shut off valve cannot be engaged when not in the priming condition.

[0008] According to a second aspect of the present invention there is provided a fuel filter assembly including the apparatus according to the first aspect of the present invention.

[0009] According to a third aspect of the present invention there is provided an internal combustion engine including the apparatus according to the first aspect of the present invention or the fuel filter assembly according to the second aspect of the present invention.

[0010] According to a fourth aspect of the present invention there is provided a method of controlling the temperature of fuel supplied to an engine, the method comprising:

receiving fuel from a fuel tank;
receiving fuel returned from an engine and
directing fuel received from an engine to one or both of a first outlet for passing fuel back to the engine and a second outlet for passing fuel to a fuel tank using a variable valve arranged to vary the proportion of fuel directed to the first and second outlets. The proportion of fuel received from the engine directed to the first and second outlets is preferably dependent upon the temperature of the fuel.

[0011] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a schematic view of an embodiment of an apparatus for controlling fuel temperature in an engine;

Figure 2 shows an apparatus for controlling fuel temperature installed in a fuel system of an internal combustion engine running under relatively cold conditions;

Figure 3 shows the fuel system of Figure 2 with an internal combustion engine running under relatively hot conditions;

Figures 4 and 5 show the fuel systems of Figures 2 and 3 with a manual shut off valve engaged during priming conditions in cold and hot conditions;

Figure 6 shows an assembled and exploded view of an example of a valve to be provided within the control apparatus;

Figure 7 shows a cross-section through the assembled valve;

Figure 8 shows a partially cut away perspective view of the outside of the apparatus;

Figure 9 is another perspective view of the outside of the apparatus showing the inlets and outlets;

Figures 10a, 10b and 10c show the position of the valve within the control apparatus when running at different temperatures;

Figure 11 shows a cross-section through the control apparatus during cold running and

Figure 12 shows a cross-section through the control apparatus during hot running conditions or when the

valve is shut off during priming at any temperature.

[0012] Figure 1 shows a schematic view of an embodiment of an apparatus 10 for controlling the temperature of fuel supplied to an engine. The apparatus 10 has a first inlet 20 for receiving fuel from a fuel tank (not shown), a second inlet 30 for receiving fuel returned from an engine (not shown), a first outlet 40 for passing fuel to an engine and a second outlet 50 for passing fuel to a fuel tank. Within the apparatus 10 is a valve for directing fuel received from the second inlet 30 to one or both of the first and second outlets 40, 50. The position of the valve is adjustable to vary the proportion of relatively hot fuel received from the second inlet 30 to be directed back to the engine via the first outlet 40 and / or to the fuel tank via the second outlet 50. The variable valve which is adjustable to vary the proportion of relatively hot fuel received from the engine via the second input 30 to be directed back to the engine enables the temperature of fuel supplied to the engine to be controlled to enhance the engine's performance. The valve determines the proportion of fuel received from the second input 30 to be returned to the engine dependent upon the fuel temperature as will be described in more detail later. The apparatus 10 includes an integrated manually operable shut off valve 60 to facilitate priming of a fuel circuit. The shut off valve 60 allows manual actuation of the variable valve such that all fuel received from the engine via the second inlet 30 is returned to a fuel tank via the second outlet 50 regardless of the fuel temperature and the variable valve position. The purpose of the shut off valve 60 is to ensure all the returned air from the engine during the priming phase is diverted back to the fuel tank and not back to the engine resulting in the permanent re-circulation of air. The variable valve is also designed in such a way that the shut off mode cannot be engaged when the priming pump function is closed off.

[0013] Figure 2 shows the apparatus 10 installed in a fuel filter assembly 100 which forms part of a fuel system 200 for an internal combustion engine. The illustrated fuel system 200 comprises a number of components making up a circuit.

[0014] Fuel is drawn from a fuel tank 210 and passes through an inlet (port 1) of the fuel filter assembly 100 to the first inlet 20 of the control apparatus 10. Fuel leaving the apparatus 10 via the first outlet 40 is then drawn through a one way valve 220 and a primer pump 230 to a primary filter media 240. Fuel is then drawn out of the fuel filter assembly 100 through Port 2 and is drawn by a supply pump 250, is passed through a cooling plate 260 to the main filter 270. After the main filter 270, a pressure sensor 280 is provided to monitor the pressure in the fuel line. The fuel is then passed to a fuel control unit 290 which passes the fuel via a high pressure pump 300 to fuel injectors in a fuel rail or head gallery in an engine's cylinder head 310 and/or through a by-pass/overflow line from the fuel control unit 290 to the exit from the cylinder head 310 to be returned to the fuel filter as-

sembly 100 via Port 3 to the second inlet 30 of the control apparatus 10. The control apparatus 10 then determines the proportion of fuel to be re-circulated via outlet 40 and the proportion of fuel to be returned to the fuel tank 210 via outlet 50. Re-circulated fuel generally mixes with fuel from the fuel tank 210 when leaving the control apparatus 10 via outlet 40.

[0015] Figure 2 illustrates an engine which is running relatively cold. In this situation the control apparatus 10 directs the majority of the relatively hot fuel received from the engine via inlet 30 back to the engine via outlet 40 with only a minority or none of the relatively hot fuel received from the engine via inlet 30 being returned to the fuel tank 210 via outlet 50. In the example of Figure 2, 90% of the relatively hot fuel received from the engine via inlet 30 is directed back to the engine via outlet 40 and the remaining 10% is returned to the fuel tank 210 via outlet 50. The variable valve in the control apparatus is arranged to be able to direct any proportion of fuel to the outlets 40, 50.

[0016] The control apparatus 10, which may comprise a thermostatic return valve, is shown schematically in Figure 2 and includes a thermostatic bulb 11 which is arranged to vary the size of a passageway from second inlet 30 to first outlet 40 depending upon the temperature of fuel passed over the thermostatic bulb 11. In this example the thermostatic bulb 11 has a pin 12 which is arranged to retract as shown in Figure 2 to pull a valve body 13 away from a valve seat 14 to open a passageway from the second inlet 30 to the first outlet 40 when the fuel is relatively cold. Conversely, when the fuel is warmer the pin 12 of the thermostatic bulb 11 extends to position the valve body 13 closer to or on the valve seat 14 to reduce the size of or close the passageway from the second inlet 30 to the first outlet 40. Such a condition is shown in Figure 3 in which none of the relatively hot fuel received from the engine via inlet 30 is re-circulated back to the engine via first outlet 40 and 100% of the relatively hot fuel is returned to the fuel tank 210. The control apparatus 10 is arranged to be adjustable to direct any proportion of fuel to first outlet 40 or second outlet 50. This enables the temperature of fuel supplied to the engine to be controlled within specified limits.

[0017] In Figures 2 and 3 the manual shut off valve 60 is not engaged. However, in Figures 4 and 5 the fuel system is shown with the manual shut off valve 60 engaged to facilitate priming of the circuit. Figure 4 shows the system priming in cold conditions and Figure 5 shows the system priming in hot conditions. However, as can be seen, in both conditions all fuel received via inlet 30 is returned to the fuel tank 210 regardless of fuel temperature and the position of the thermostatic bulb 11 and shaft 12. Use of the shut off valve 60 ensures that all the returned air from the fuel system during the priming phase is diverted back to the fuel tank 210 and not the engine which could result in the permanent re-circulation of air and possible subsequent starting problems.

[0018] Figure 6 shows an assembled and exploded

view of an example of a valve which may be provided within the control apparatus 10 and Figure 7 shows a cross-section through the assembled valve.

[0019] The valve comprises a thermal bulb 500 (equivalent to the thermostatic bulb 11 shown in Figures 2 to 5) housed and supported in a cartridge end cap 510. A spool 520 is inserted onto a thermal bulb pin and retained by return spring 530 in a housing of the fuel filter assembly 100. A seal 540 fits and seals onto a spool shaft by means of an inner lip and is retained by a spring 550 against a spool stop shoulder 560. The spool 520 with seal 540 retained by springs 530 and 550 can move inside the assembly of the cage 570 and cartridge end cap 510 depending upon the position of thermal bulb pin. The amount of relatively hot fuel returned back to the fuel tank 210 via the second outlet 50 (Figures 1 to 5) is determined by the valve stroke distance between the sealing face of lip seal 580 and cage orifice 590 (see Figures 6 and 7).

[0020] Thermal bulb 500 contains wax which expands and contracts depending upon the temperature of fuel. As the thermal bulb 500 expands due to a temperature increase, the thermal bulb pin 600 will extend and move spool 520 causing movement of seal 540 until it comes into contact with cage orifice 590. At this point the sealing contact between the sealing face 580 of lip seal 540 and the cage orifice 590 is reached. Sealing pressure is provided by the load of spring 550 and the compression of lip 610 over spool shaft 620. In this hot running condition as shown in Figure 3 the second inlet 30 (Port 3) becomes sealed from the first outlet 40 (Port 2) and the first inlet 20 (Port 1) and all of the relatively hot re-circulated fuel from second inlet 30 (Port 3) is returned to the fuel tank 210 via second outlet 50 (Port 4). The valve is designed in such a way as to be able to accommodate further temperature expansion of the thermal bulb 500 and extension of the thermal bulb pin 600 and movement of spool 520.

[0021] When the wax in the thermal bulb 500 cools and contracts, the spool 520 and thermal bulb pin 600 are retracted by the spring force from return spring 530. The load from return spring 530 is exerted onto the sealing face 580 of lip seal 540 causing lip seal 540 to lift away from the cage orifice 590 and open a passageway from second inlet 30 (Port 3) to first outlet 40 (Port 2) and first inlet 20 (Port 1) as shown in Figure 2.

[0022] Figure 8 shows a partially cut-away perspective view of the outside of apparatus 10 and Figure 9 is another perspective view of the outside of apparatus 10 showing the inlets and outlets.

[0023] Figures 10a, 10b and 10c show the position of the variable valve within apparatus 10 at various fuel temperatures with the shut off valve disengaged.

[0024] Figure 10a shows the apparatus 10 during cold running with fuel at less than +15°C. In this condition the valve is fully open with 90% of the relatively hot fuel received at the second inlet 30 (Port 3) returned to the engine via the first outlet 40 (Port 2) and the other 10% returned to the fuel tank via second outlet 50 (Port 4).

Directing the majority of the relatively hot fuel back to the engine enables it to warm up more quickly enhancing its performance.

[0025] Figure 10b shows the apparatus 10 during hot running with fuel between +15 and +30°C. In this condition a smaller proportion of relatively hot fuel received at the second inlet 30 (Port 3) is returned to the engine via the first outlet 40 (Port 2).

[0026] Figure 10c shows the apparatus 10 during hot running with fuel above 30°C. In this condition all of the relatively hot fuel received at the second inlet 30 (Port 3) is returned to the fuel tank via the second outlet 50 (Port 4).

[0027] Figure 11 shows a cross-section through the control apparatus 10 during cold running at below +15°C. In this condition there is a gap 700 for 90% of the fuel returning from the engine via inlet 30 (Port 3) to be returned to the engine via outlet 40 (Port 2). The remaining 10% of the fuel is returned to the fuel tank.

[0028] Figure 12 shows the same cross-section as Figure 11 except with the fuel at more than +30°C. In this condition a valve body is in contact with a valve seat so that none of the fuel returning from the engine via inlet 30 (Port 30) is returned to the engine. Instead, it is all returned to the fuel tank.

[0029] The shut off valve works by manually creating the same situation as with hot fuel. The handle of the shut off valve 60 is rotated and translated forward until it contacts the thermal bulb 500. This then forces a valve body into contact with a valve seat preventing fuel received from the engine via second inlet 30 (Port 3) from being re-circulated back to the engine via first outlet 40 (Port 2). Instead, all of the fuel from second inlet 30 (Port 3) is returned to the fuel tank.

[0030] Many modifications may be made to the examples described above whilst still falling within the scope of the invention. For example, the apparatus 10 may include a temperature sensor to determine the temperature of the fuel and a control means such as a microprocessor to adjust the position of the valve and thus the proportion of the fuel directed to the first and second outlets dependent upon the measured temperature. Furthermore, any suitable type of valve may be provided as either the variable valve or shut-off valve or both.

Claims

1. An apparatus for controlling the temperature of fuel supplied to an engine, the apparatus comprising:

- a first inlet for receiving fuel from a fuel tank;
- a second inlet for receiving fuel returned from an engine;
- a first outlet for passing fuel to an engine;
- a second outlet for passing fuel to a fuel tank and
- a valve for directing fuel received from the second inlet to one or both of the first and second

- outlets wherein the valve is arranged to vary the proportion of fuel directed to the first and second outlets.
2. An apparatus according to claim 1, wherein the valve is arranged to vary the proportion of fuel directed to the first and second outlets dependent upon the fuel temperature. 5
 3. An apparatus according to claim 2, wherein the valve is arranged to vary the proportion of fuel directed to the first and second outlets dependent upon the temperature of the fuel in the apparatus. 10
 4. An apparatus according to claim 3, wherein the valve is arranged to vary the proportion of fuel directed to the first and second outlets dependent upon the temperature of the fuel at the first and second inlets. 15
 5. An apparatus according to any one of the preceding claims, wherein the valve has a valve body and a valve seat and the distance between the valve body and the valve seat is controlled to determine the proportion of fuel directed to the first and second outlets. 20
 6. An apparatus according to claim 5, wherein the valve body is moved relative to the valve seat in accordance with the fuel temperature. 25
 7. An apparatus according to claim 6, wherein the valve has an expanding and contracting portion connected to the valve body which expands and contracts in accordance with the fuel temperature to move the valve body relative to the valve seat. 30
 8. An apparatus according to claim 7, wherein expansion of the expanding and contracting portion moves the valve body toward to valve seat, thereby to direct a larger proportion of fuel to the second outlet. 35
 9. An apparatus according to claim 8, wherein the valve body is biased to move away from the valve seat on contraction of expanding and contracting portion. 40
 10. An apparatus according to any one of claims 7 to 9, wherein the expanding and contracting portion comprises a thermostatic bulb. 45
 11. An apparatus according to any one of the preceding claims, wherein the valve directs more of the fuel received from the second inlet to the first outlet when the fuel is below a predetermined temperature. 50
 12. An apparatus according to any one of the preceding claims, wherein the valve directs less of the fuel received from the second inlet to the first outlet when the fuel is above a predetermined temperature. 55
 13. An apparatus according to any one of the preceding claims, including a shut off valve to facilitate priming of a fuel circuit by passing all of the fuel and/or air received from the second inlet to the fuel tank via the second outlet.
 14. An apparatus according to claim 13, wherein the shut off valve is operable to pass all of the fuel and/or air received from the second inlet to the fuel tank via the second outlet regardless of the position of the variable valve.
 15. An apparatus according to claim 15, wherein the shut off valve is operable to actuate the variable valve to pass all of the fuel and/or air received from the second inlet to the fuel tank via the second outlet regardless of the position of the variable valve.
 16. An apparatus according to claim 16, wherein a portion of the shut off valve is translatable to force a valve body of the variable valve into contact with a valve seat of the variable valve.
 17. An apparatus according to any one of claims 13 to 16, wherein the shut off valve is manually operable.
 18. An apparatus according to any one of claims 13 to 17, wherein the shut off valve cannot be engaged when the apparatus is not in a priming condition.
 19. A fuel filter assembly including the apparatus according to any one of the preceding claims.
 20. An internal combustion engine including the apparatus according to any one of claims 1 to 18 or the fuel filter assembly according to claim 19.
 21. A method of controlling the temperature of fuel delivered to an engine, the method comprising:
 - receiving fuel from a fuel tank;
 - receiving fuel returned from an engine and
 - directing fuel received from an engine to one or both of a first outlet for passing fuel back to the engine and a second outlet for passing fuel to a fuel tank using a variable valve arranged to vary the proportion of fuel directed to the first and second outlets.
 22. A method according to claim 21, wherein the proportion of fuel received from an engine directed to the first and second outlets is dependent upon the temperature of the fuel.
 23. A method according to claim 21 or claim 22, the method comprising using a shut off valve to facilitate priming of a fuel circuit by passing all of the fuel and/or air received from the second inlet to the fuel

tank via the second outlet.

- 24.** A method according to claim 23, wherein the shut off valve passes all of the fuel and/or air received from the second inlet to the fuel tank via the second outlet regardless of the position of the variable valve. 5
- 25.** A method according to claim 24, comprising using the shut off valve to actuate the variable valve to pass all of the fuel and/or air received from the second inlet to the fuel tank via the second outlet regardless of the position of the variable valve. 10
- 26.** A method according to claim 25, wherein said actuating comprises translating a portion of the shut off valve to force a valve body of the variable valve into contact with a valve seat of the variable valve. 15
- 27.** A method according to any one of claims 21 to 26, comprising manually operating the shut off valve. 20
- 28.** A method according to any one of claims 21 to 27, comprising engaging the shut off valve only when the apparatus is in a priming condition. 25

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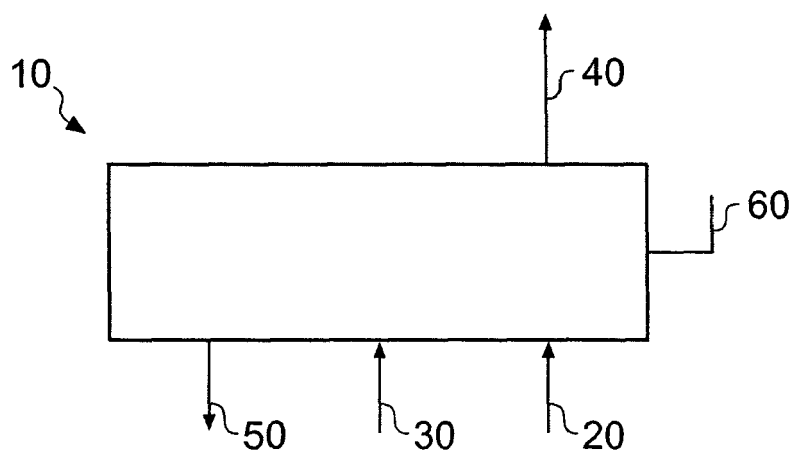


Fig. 1

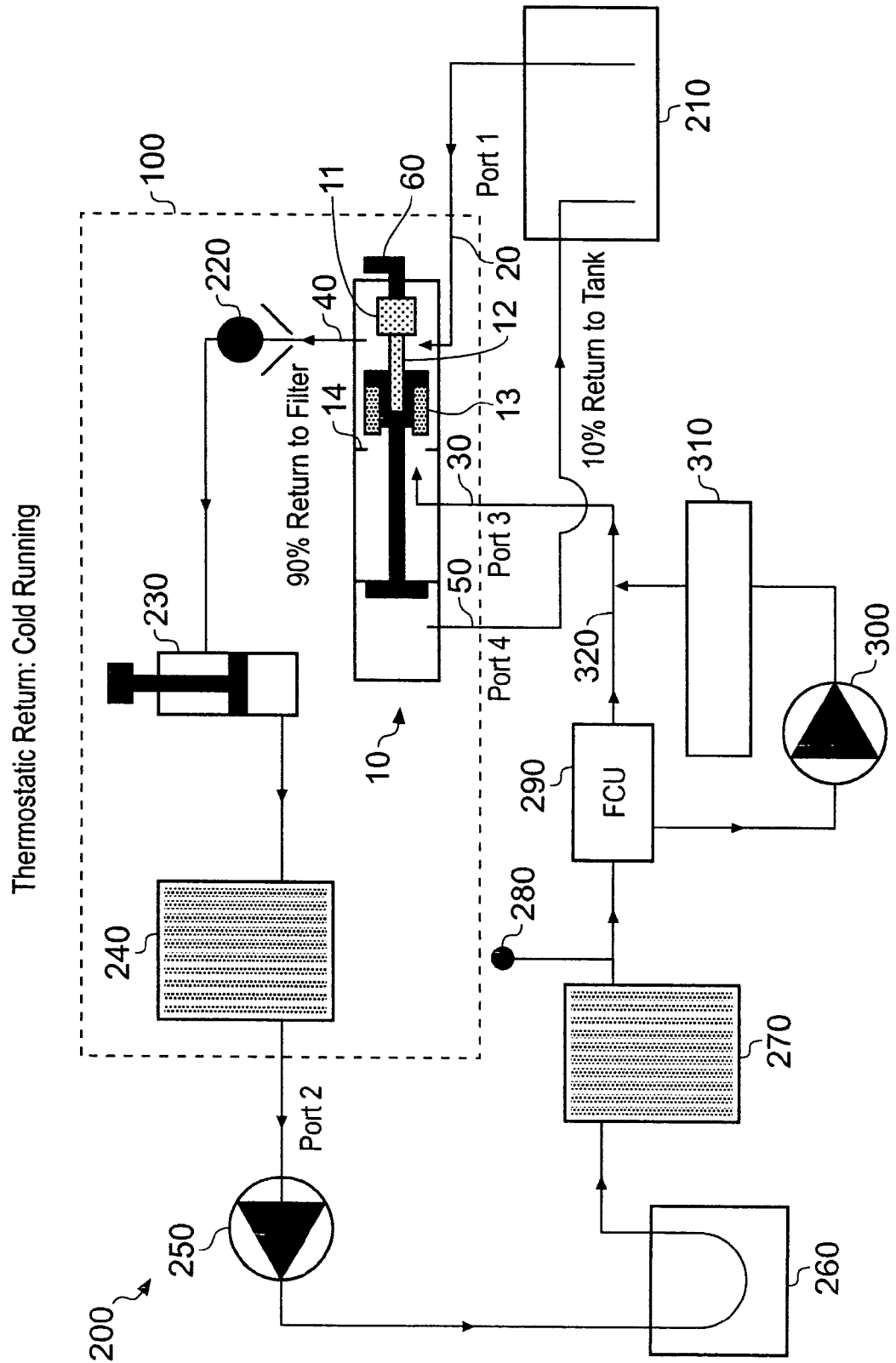
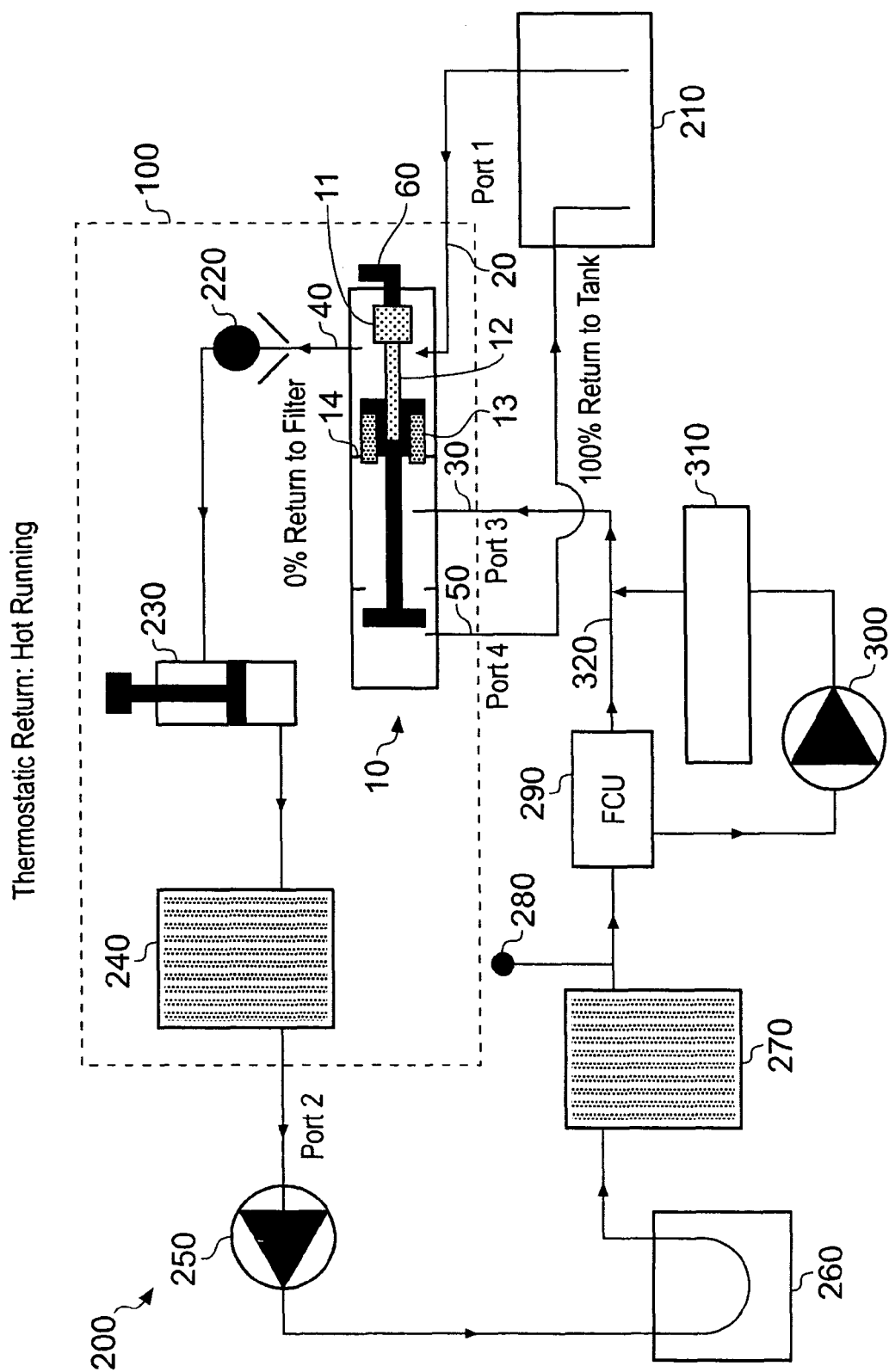


Fig. 2



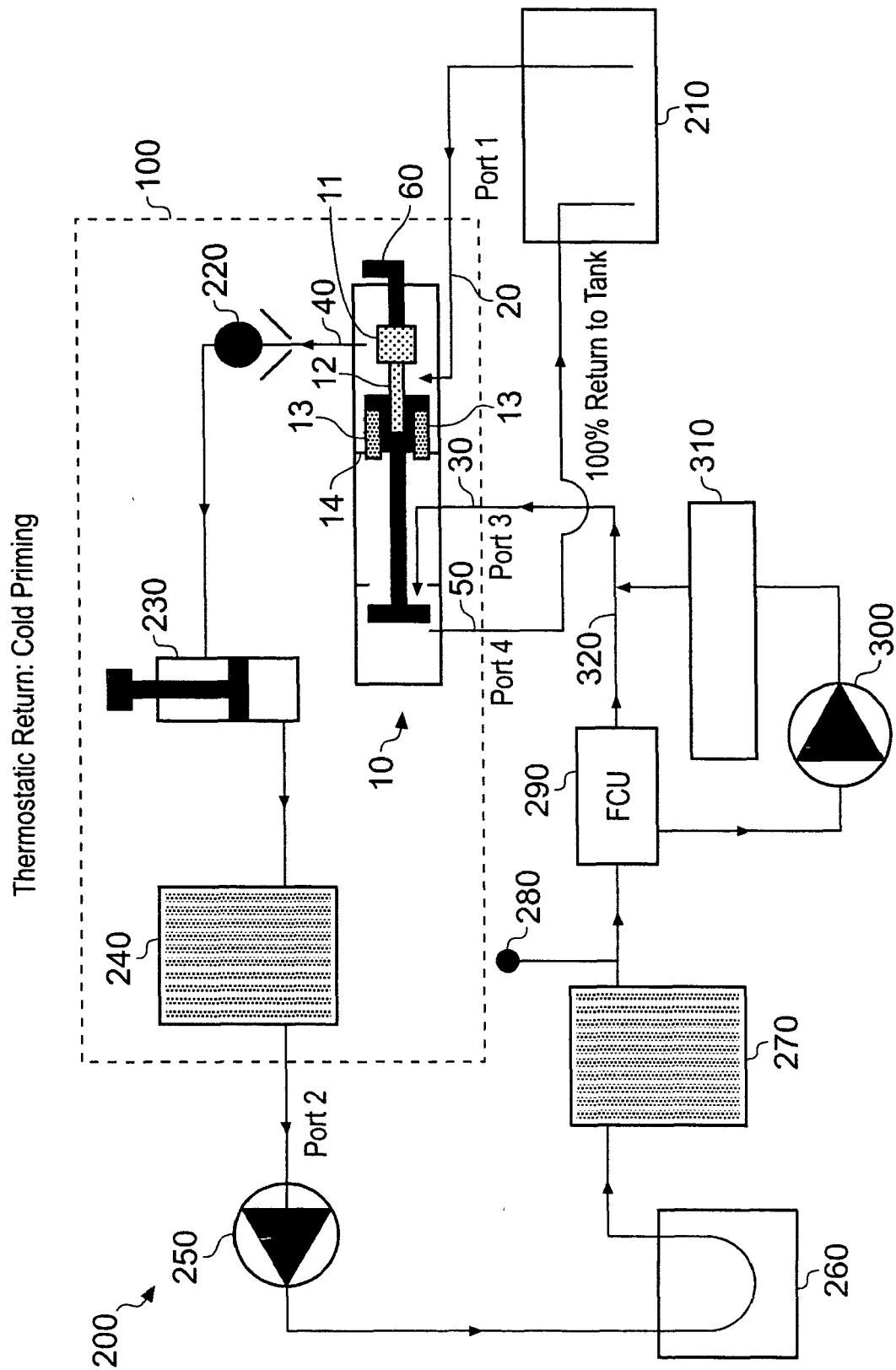


Fig. 4

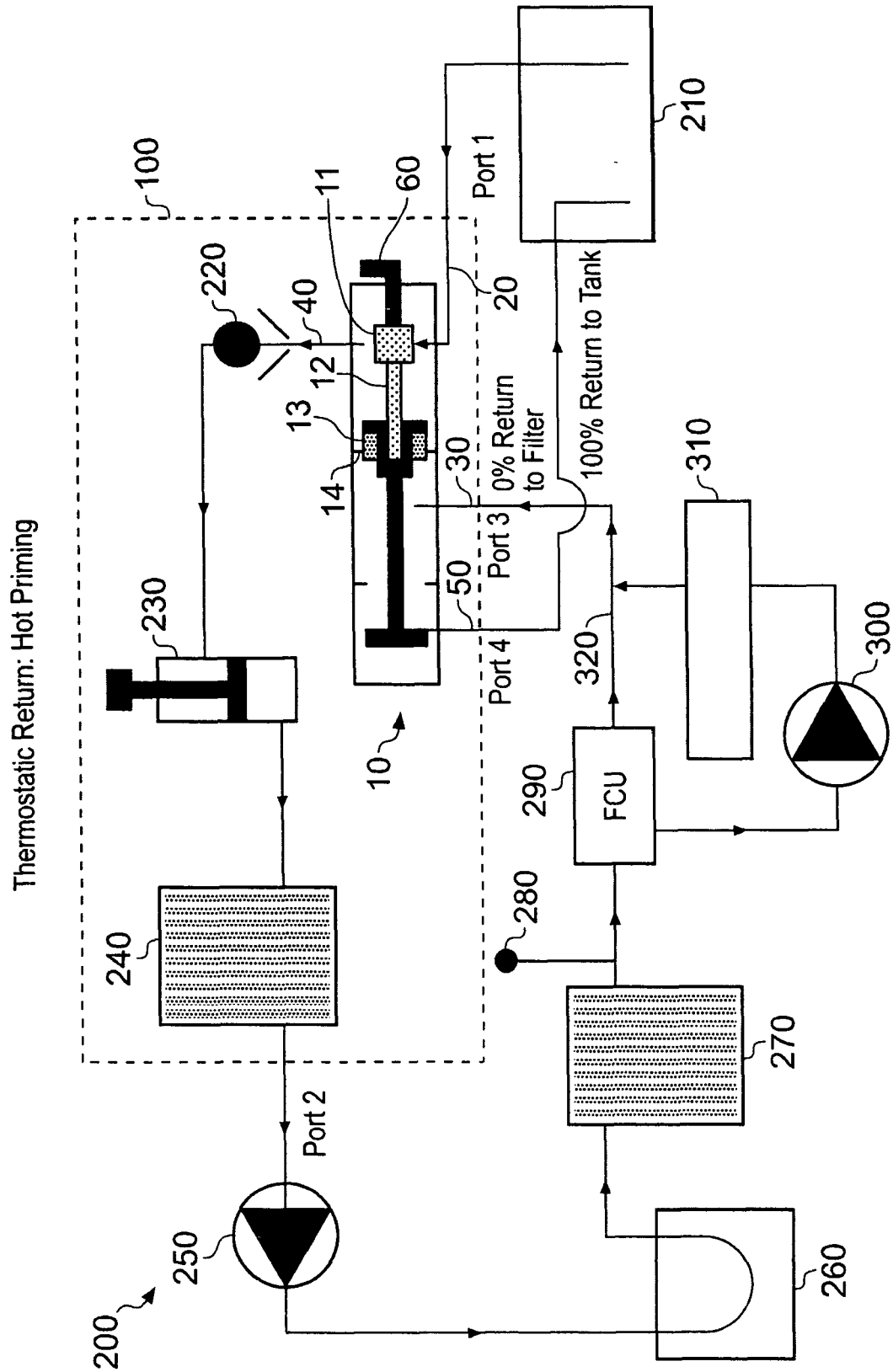


Fig. 5

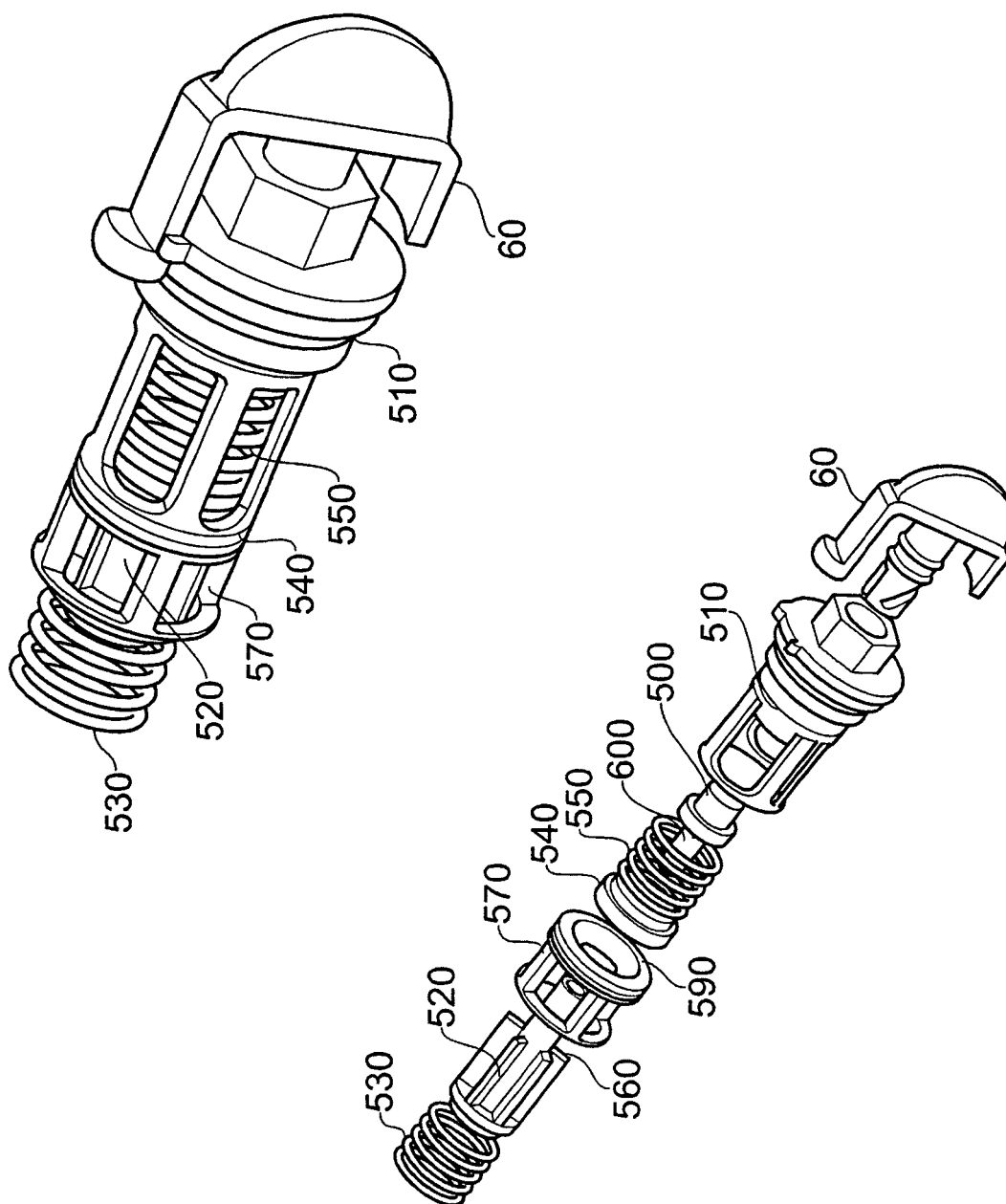


Fig. 6

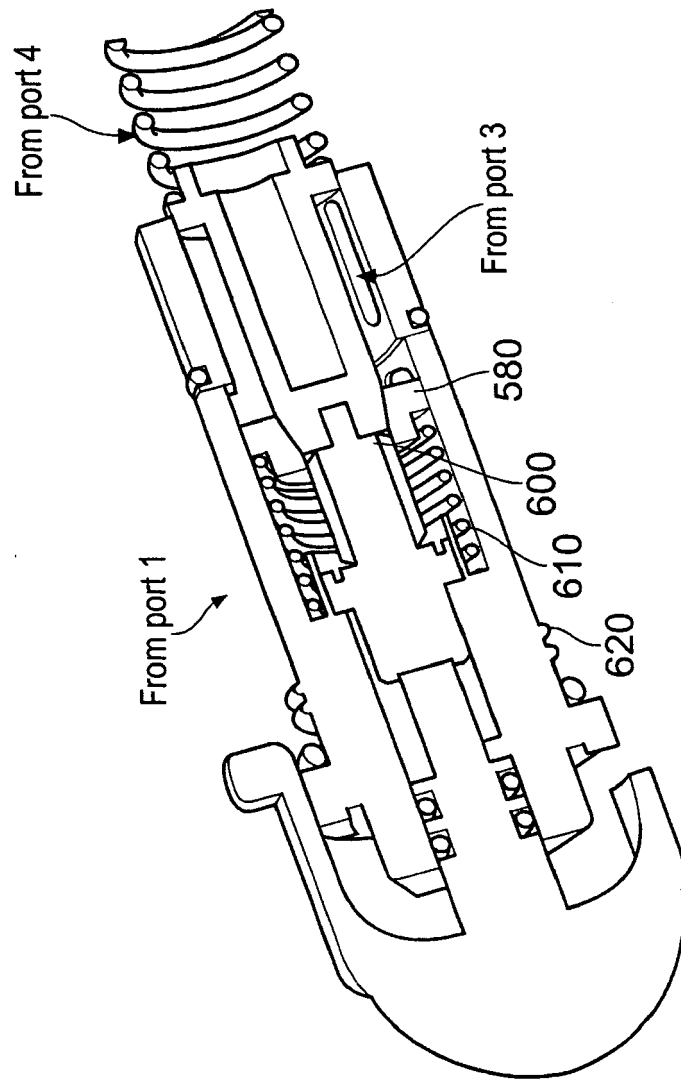


Fig. 7

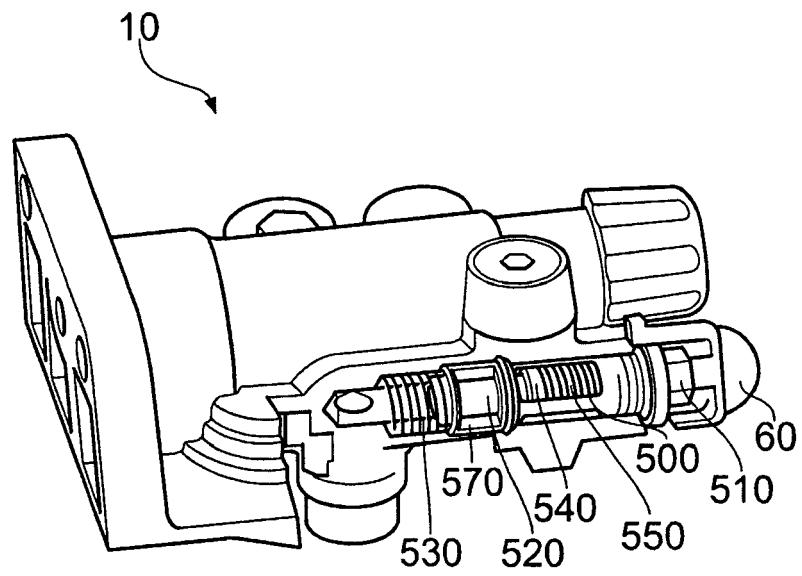


Fig. 8

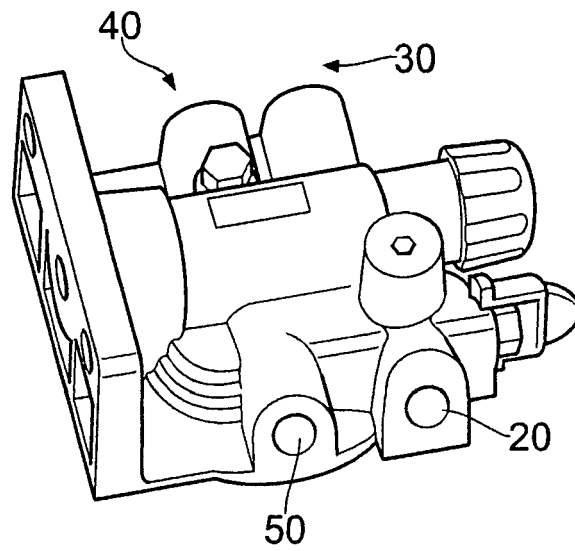
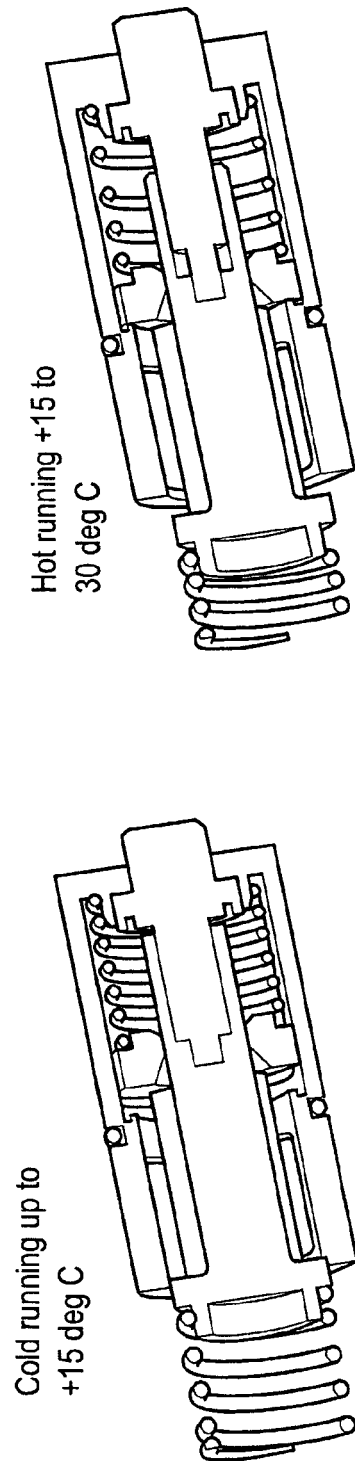


Fig. 9



Valve is fully open:
80% fuel flow returns to filter
20% fuel returns to tank

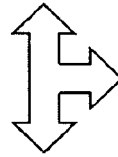


Fig. 10a

Valve is moving to close

Fig. 10b

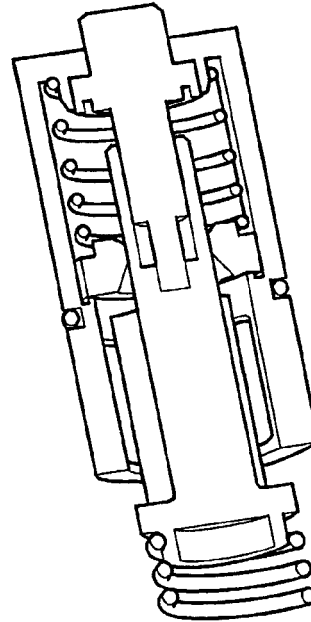


Fig. 10c

THERMAL VALVE
OPEN POSITION <15°C

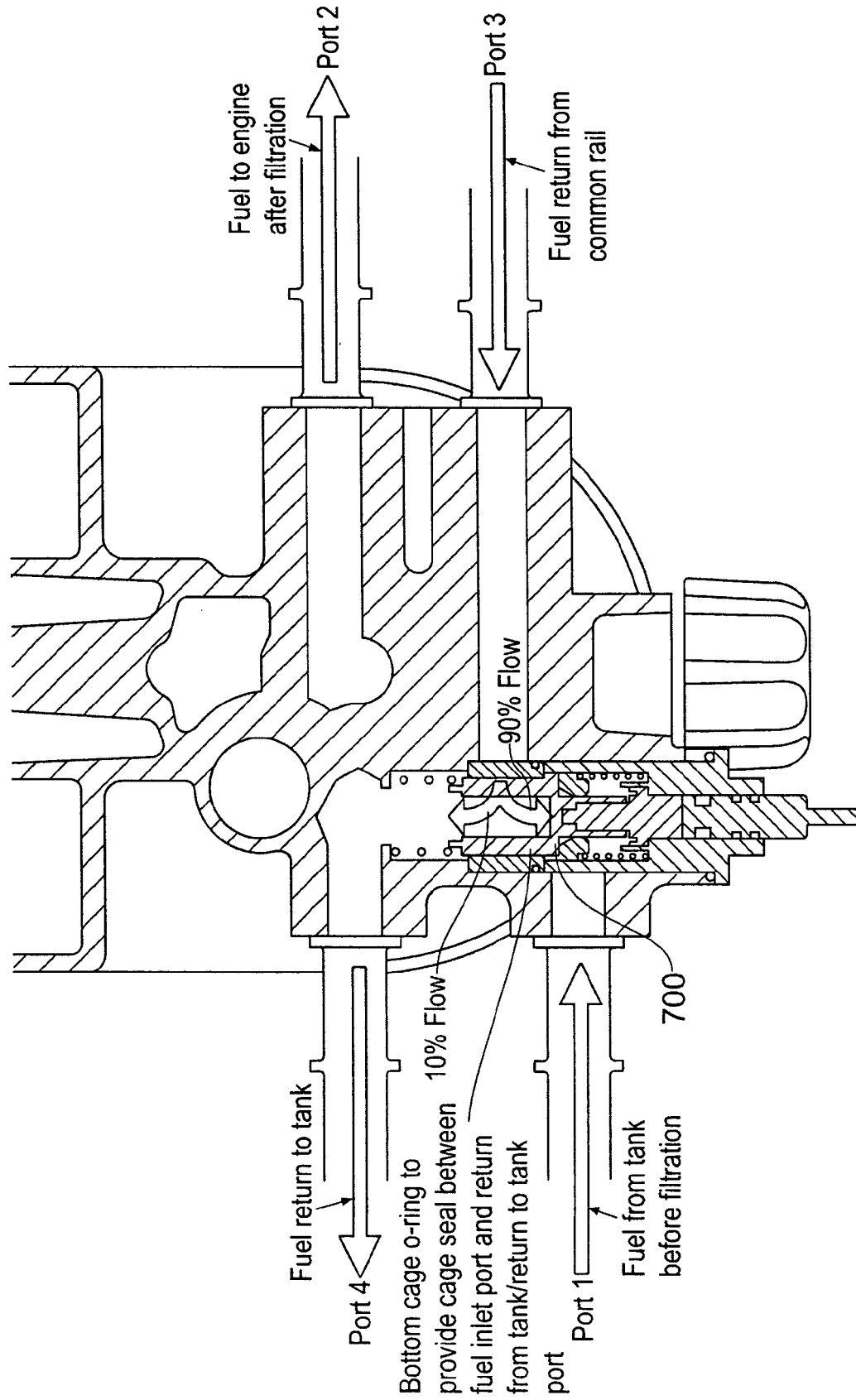


Fig. 11

