

Engine Cooling Systems

This invention relates to engine cooling systems particularly but not exclusively for motor vehicles having a liquid cooled engine.

Typically, a motor vehicle cooling system comprises a primary cooling circuit having an air-cooled radiator for cooling a liquid coolant for the engine. A pump circulates the coolant through the engine and then to the radiator or to a bypass through an engine return line and back to the pump through a thermostatic flow control valve or main thermostat and a pump return line. Coolant cooled by the radiator passes through a radiator return line to the main thermostat and then back to the pump through a pump return line. The main thermostat controls the flow through the radiator, preventing flow until the engine has reached an appropriate running temperature.

It is known to use the main engine coolant to cool one or more additional heat exchangers such as exhaust gas recirculation (EGR) cooler forming part of an exhaust gas recirculation (EGR) system. An example of an EGR cooler is shown in US-A-6141961. In one known arrangement, the EGR cooler is connected between the hot delivery line from the engine and the cold return to the pump. This has a disadvantage in that the EGR cooler ceases to be effective once the engine and cooling system have warmed up to a significant degree. To overcome this, it has been proposed to connected the EGR cooler between the cold radiator return line from the engine and the cold return to the pump. However, this requires a thermostatic flow control valve which relies on a minimal coolant flow through the EGR cooler to be able to sense the coolant temperature. This minimal flow robs the engine and cooling system of valuable heat during the initial warm-up phase since it passes through the radiator and is thus cooled down from engine delivery temperature right down to ambient temperature.

It is an object of this invention to provide an improved cooling system which helps to alleviate such problems.

- 2 -

According to a first aspect of the invention there is provided an engine cooling system comprising a primary cooling circuit having a radiator for cooling liquid coolant for the engine, a pump to circulate the coolant through an engine supply line to the engine, from the engine to the radiator and from the radiator back to the pump through a pump return line, an auxiliaries cooling circuit having at least one auxiliary heat exchanger for cooling one or more further liquids and arranged so that coolant can flow from the engine supply line through the or each auxiliary heat exchanger and be returned as an auxiliaries return flow into the pump return line wherein a common control valve is provided between the or each auxiliary heat exchanger and the pump return line and between the heater and the pump return line to control both the auxiliaries return flow and the heater return flow.

Preferably, the common control valve is operable to prevent the auxiliaries return flow until the temperature of the heater return flow reaches a first predetermined temperature.

The common control valve may be operable to restrict the heater return flow when the temperature of the heater return flow exceeds a second predetermined temperature.

Alternatively, the common control valve may be operable to restrict the heater return flow when a combination of the temperature of the auxiliaries return flow and the temperature of the heater return flow exceeds a second predetermined temperature. In either case there may be substantially no heater return flow allowed when the temperature of the heater return flow exceeds the second predetermined temperature. This second predetermined temperature of temperature is usually an indication that no heat output is being taken from the heater so this can be used to optimise the performance of the or each auxiliary heat exchanger.

Conveniently, the common control valve comprises a thermally-responsive actuator having a temperature sensitive portion that is exposed to at least one of said return flows, in which case the temperature sensitive portion may be exposed to only the heater return flow when the temperature of the heater return flow is below the first predetermined

- 3 -

temperature. Alternatively, the temperature sensitive portion may be exposed to both the heater return flow and the auxiliaries return flow.

When the common control valve permits both the auxiliaries return flow and the heater return flow, the auxiliaries return and the heater return flows may be mixed prior to reaching
5 said temperature sensitive portion so that the temperature sensed by the temperature sensitive portion is dependent upon a combination of the temperature and the flow rate of the heater return flow and the temperature and flow rate of the auxiliaries return flow.

The auxiliaries cooling circuit may comprise two or more of said auxiliary heat exchangers arranged in parallel. Typically the auxiliary heat exchangers include an engine
10 oil cooler, one or more transmission oil coolers and/or a fuel cooler.

In a preferred arrangement the common control valve comprises a housing defining a valve chamber, a first inlet connecting the heater to the valve chamber for the heater return flow, a second inlet connecting the or each auxiliary heat exchanger to the valve chamber for the auxiliaries return flow, an outlet connected to the pump return line and a valve
15 assembly mounted in the valve chamber, the valve assembly comprising a valve shuttle and a biasing means to bias the valve shuttle towards an auxiliaries closed position in which heater return flow through the first inlet to the outlet is substantially unrestricted while auxiliaries return flow through the second inlet is prevented. Where the common control valve includes the thermally-responsive actuator, the valve assembly may further comprise
20 the thermally-responsive actuator, the thermally-responsive actuator being arranged to urge the valve shuttle against the biasing means to allow auxiliaries return flow through the second inlet to the outlet when the temperature of the heater return flow reaches the first predetermined temperature while continuing to allow the heater return flow from the first inlet through to the outlet.

- 4 -

The valve shuttle may be arranged so that with increasing temperature of the heater return flow, it moves further against the biasing means to obstruct heater return flow through the first inlet when the temperature of the second predetermined temperature is attained while continuing to allow the auxiliaries return flow from the second inlet through to
5 the outlet.

Preferably, the valve shuttle has a main valve member which cooperates with the housing to close the second inlet. In such a case, when the valve shuttle is arranged so that it obstructs heater return flow through the first inlet when the temperature of the second predetermined temperature is attained, the main valve member may be arranged to
10 cooperate with the housing to obstruct the first inlet. Alternatively and under the same circumstances, the valve shuttle may have an ancillary valve member which cooperates with the housing to obstruct the first inlet.

The thermally-responsive actuator may comprise an actuator body fast with the valve shuttle and a pushrod extending from one end of the valve shuttle for cooperation with an
15 abutment on the housing, the actuator body including said temperature sensitive portion. Conveniently, the abutment is in the second inlet.

The biasing means may be a helical spring. The helical spring may be axially guided by the housing, conveniently by being located in the first inlet. In such cases, the valve shuttle may have a fluted end portion which is engaged within the helical spring so that the
20 valve shuttle is axially guided by the helical spring.

Conveniently, where the thermally-responsive actuator comprises an actuator body fast with the valve shuttle, the valve shuttle is shaped to allow coolant to directly contact the temperature sensitive portion of the actuator body. In such a case valve shuttle may be shaped to allow coolant to directly contact the temperature sensitive portion on the side of
25 the main valve member towards the first inlet and on the side of the main valve member

- 5 -

towards the second inlet. Alternatively, where the valve shuttle comprises the ancillary valve member, the valve shuttle may be shaped to allow coolant to directly contact the temperature sensitive portion of the actuator body between the main valve member and the ancillary valve member and on the side of the main valve member towards the first inlet.

- 5 The invention also provides, according to a second aspect thereof, a common control valve when used in an engine cooling system according to a said first aspect

The invention will now be described by way of example and with reference to the accompanying drawings, of which:-

Fig.1 is a diagrammatic representation of an engine cooling system according to the
10 invention; and

Fig.2 is a cross-section through a secondary flow control valve shown in Fig.1.

With particular reference to Fig.1, a motor vehicle cooling system 10 comprises a primary cooling circuit having an air-cooled radiator 8 for cooling a liquid coolant for the engine 3. A pump 2 circulates the coolant through the engine 3 and then to the radiator 8
15 or to a bypass BL through an engine return line ER. Coolant from the radiator 8 and the bypass BL is returned to the pump 2 through a primary flow control valve 5 and a pump return line RL. The primary flow control valve 5 is usually simply referred to as the thermostat. Here it will be referred to as the main thermostat 5 to avoid any confusion with other parts of the cooling system. An appropriate main thermostat 5 is described in
20 EP-A-0794327 although conventional thermostats may be used. The bypass BL is arranged in parallel to the radiator 8 between the engine return line ER and the main thermostat 5. Coolant that has been cooled by the radiator 8 passes along a radiator return line RR to the main thermostat 5 and then back to the pump 2 through a pump return line RL. The main thermostat 5 controls the flow through the radiator 8, preventing flow until
25 the engine 3 has reached an appropriate running temperature. However, as with most valves of this type, the main thermostat 5 also controls the flow in the bypass line BL. An

- 6 -

expansion tank 9 is connected at an upper end to the top of the radiator 8 by a degas supply line DS and is connected at a lower end to the return line RL by a degas return line DR.

The engine cooling system 10 also includes an auxiliaries cooling circuit for an auxiliary heat exchanger which, in this example, is an exhaust gas recirculation (EGR) cooler 16 connected to the engine return line ER and the radiator return line RR through a secondary flow control valve 20, more conveniently referred to as the EGR mixer valve. The EGR mixer valve 20 has a first inlet connected to the engine return line ER and a second inlet connected to the radiator return line RR. Coolant is supplied to the EGR cooler 16 from an outlet 33 in the EGR mixer valve 20 through a cooler supply line CS while the coolant output from the EGR cooler 16 is delivered to the pump return line RL through a restrictor 22.

Also included in the engine cooling system 10 is a heater circuit comprising a heater 4 having a liquid to air heat exchanger for vehicle cabin heating. The heater 4 is connected by a heater supply line HS to the engine return line ER between the engine 3 and the radiator 8. After flowing through the heater 4, the coolant is returned to the pump return line RL.

With further reference to Fig.2, the EGR mixer valve 20 comprises a housing 30 made as a one-piece plastics moulding defining the first inlet 31, the second inlet 32, the outlet 33 and a valve chamber 41. The housing 30 is in the form of a conventional tee-piece for connection to flexible hoses, the first and second inlets 31 and 32 being axially aligned and the outlet 33 having its axis perpendicular to that of the inlets. A valve assembly 42 is carried in the valve chamber 41 and comprises a valve shuttle 24 formed as a plastics moulding and a thermally-responsive actuator 19 carried partly within the shuttle 24. A biasing means in the form of a helical spring 22 acts to bias the shuttle 24 towards the second inlet 32. The valve chamber 41 is formed as an extension of the bore of the first

- 7 -

inlet 31 and at a step of this bore with the smaller bore of the second inlet 32 a chamfered valve seat 43 is formed for cooperation with a corresponding valve seat on a main valve member 25 formed as a collar integral with the shuttle 24. An outlet port 33A is provided in the bore of the first inlet 31 to connect the valve chamber 41 with the outlet 33. This outlet
5 port 33A is located at the end this bore nearest to the second inlet 32 and has a relatively small cross-sectional area compared to the cross-sectional area of either of the first and second inlets 31 and 32.

The thermally-responsive actuator 19 is a conventional wax actuator (generally referred to as wax capsule) having an actuator or capsule body 21 and a pushrod 28
10 extending towards the second inlet 32 for cooperation with an abutment 29 in the second inlet 32. The abutment 29 is carried on three spokes and is formed as an integral part of the housing 30. The capsule body 21 has a metal casing which forms a temperature sensitive portion which can transmit heat to wax for driving the pushrod 28. The capsule body 21 is cylindrical, having a small diameter portion 21A which is a push fit in a bore 24A
15 of the shuttle 24 and a large diameter portion 21B. A step between the small diameter portion 21A and the large diameter portion 21B provides an abutment with the shuttle 24. The shuttle 24 has four radial fins 27 which form a fluted end portion at its end adjacent the first inlet 31. Each fin 27 is aligned with a corresponding longitudinal rib 27A, the bore 24A intersecting with the ribs 27A to define four apertures 24A to the side of the main valve
20 member 25 which is towards the first inlet 31. These apertures 24A allow coolant from the first inlet 31 to directly contact the capsule casing 21 on the side of the main valve member 25 which is towards the first inlet 31. On the other side of the main valve member 25 coolant from the second inlet 32 can contact the large diameter portion 21B of the capsule body 21 as well as the area of the small diameter portion 21A which is between the large
25 diameter portion 21B and the valve member 25 as exposed by the open ends of the ribs 27A.

- 8 -

Each fin 27 has a step 26 to provide a reaction surface for the helical spring 22. The helical spring 22 is a sliding fit on the fins 27 while the spring 22 is a sliding fit in the bore of first inlet 31. Hence the helical spring 22 acts as a guide for the valve shuttle 24. A ladder-shaped retainer 23 extends across the first inlet 31 through diametrically opposed
5 windows in the housing 30 to provide a reaction surface for the helical spring 22.

Operation of the primary cooling circuit is conventional and thus will be described relatively briefly. When the engine 3 is started from cold it is desirable to increase its temperature as quickly as possible to reduce emissions and to increase fuel economy. During initial running of the engine, the main thermostat 5 prevents any coolant flowing
10 through the radiator 8 while allowing flow through the bypass BL. Once the engine 3 has reached its normal operating temperature, in this case 90°, the main thermostat 5 starts to close off the bypass BL to allow coolant to begin flowing through the radiator 8 and prevent the engine 3 from overheating.

Operation of the EGR mixer valve 20 is as follows. Following a cold start of the
15 engine 3, the valve 20 is in the state shown in Fig.2. The main valve member 25 is held on the seat 43 by the spring 22 to shut off the flow from the radiator return line RR through the second inlet 32 while allowing flow from the engine return line ER through the first inlet 31 into the valve chamber 41 and through the outlet port 33A at a flow rate controlled by the restrictor 22. Because the capsule body 21 is exposed to coolant from both the first inlet
20 31 and the second inlet 32 the capsule body 21 senses an combination of the temperatures of the coolant in the first and second inlets. Therefore, as the temperature of the engine return flow increases, the pushrod 28 can generate a force in opposition to the preload of the spring 22. However, the radiator return flow remains blocked so long as the sensed temperature is below a first predetermined temperature, which is more conveniently
25 referred to as the opening temperature, which in this example is 35°C. This sensed temperature is an average of the temperatures of the coolant in the first and second inlets, weighted by the ratio of the areas of the capsule body 21 exposed on either side of the

- 9 -

valve member 25. For example, if the temperature at the first inlet 31 is t_1 and the area exposed is A_1 while the temperature at the second inlet 32 is t_2 and the area exposed is A_2 , the sensed temperature would be approximately $(t_1.A_1+t_2.A_2) / (A_1+A_2)$. At the opening temperature the force generated by the pushrod 28 overcomes the pre-load of the spring
5 22 and the shuttle 24 starts to move away from the second inlet 32 to allow coolant from the radiator return line to flow from the second inlet 32 to the outlet 33 while continuing to allow coolant from the engine return line ER to flow from the first inlet 31 to the outlet 33.

As the temperature in the engine return line continues to rise, the force generated by the wax actuator 19 continues to increase and the shuttle 24 is moved further away from
10 the second inlet 32. At a second predetermined sensed temperature, in this case approximately 40°C, the valve member 25 moves past the outlet port 33A and obstructs the bore of the first inlet 31 to impede the flow of coolant from the engine return line ER. There is a small working clearance between the valve member 25 and the bore of the first inlet 31 which allows a small flow of the relatively hot coolant to continue to flow from the first inlet
15 31 so that the capsule body 21 continues to sense the engine return line temperature as previously described. With further increases in the sensed temperature, the pushrod 28 becomes fully extended and the valve member 25 is positioned more or less in the middle of the outlet 33.

By preventing radiator return flow in the period following a cold start of the engine 3
20 and until the sensed temperature reaches 35°C, there is no loss of heat through the radiator 8 so the engine can warm up as quickly as possible. A further advantage of preventing or delaying flow through the radiator is that there is less stress on the radiator 8 caused by thermal cycling, particularly the heating of one area of the radiator core more than another when the flow rate is very low. This is a problem which can be particularly
25 acute in cross-flow type radiators when the low rate means that hot flow is through the top one or two tubes only.

- 10 -

By sensing a combination of the temperatures of the coolant in the first and second inlets 31 and 32, the EGR mixer valve 20 is able to automatically compensate for different ambient temperatures. For example, if the temperature t_1 at the first inlet 31 is 35°C (i.e. the engine 3 is just starting to warm up) and the area exposed $A_1 = 1\text{cm}^2$ while the ambient temperature t_2 at the second inlet 32 is 15°C and the area exposed A_2 is 2cm^2 , then the sensed temperature according to the weighted average formula given above would be $(35 \times 1 + 15 \times 2) / (1 + 2)$, i.e. approximately 22°C, which is below the opening temperature. At this same ambient temperature of 15°C the temperature of the coolant in the first inlet 31 has to rise to 75°C for the EGR valve 20 to start to open. At a lower ambient temperature of, say 5°C, the second inlet will remain closed until the temperature of the coolant in the first inlet reaches a significantly higher figure of 95°C because $(35 \times 1 + 5 \times 2) / (1 + 2) = 95$. In this situation, the EGR valve 20 remains closed to flow from the radiator return line until the engine 3 has reached its normal running temperature. Conversely, if the vehicle is operating in a higher ambient temperature of 30°C then the second inlet will be open at a significantly lower figure of 45°C, i.e. very soon after engine start up. Significantly higher ambient temperatures change the operation of the EGR mixer valve 20 altogether. For example, at an ambient temperature of 35°C the valve is starting to open and at ambient temperatures higher than this the valve will be already open because the sensed temperature at engine start up will exceed the opening temperature. At these higher ambient temperatures the heater 4 will not be used (except to moderate air conditioner output) and there is no detrimental effect by having the radiator 8 in immediate use because the engine 3 will reach its operating temperature very quickly.

It will be appreciated that the temperature of the coolant in the first inlet 31 is substantially the same as the temperature of the coolant leaving the engine 3 because of the constant flow through the first inlet while the engine 3 and the pump 2 are running. During the closed and opening phases of operation of the EGR valve 20, the temperature of the coolant in the second inlet 32 is substantially equal to ambient temperature, whether the second inlet is open or closed. This is because the temperature starts at ambient and

- 11 -

remains at ambient while there is no flow through the second inlet 32. When the valve 20 starts to open, the flow through the second inlet 32 is low relative to the size of the radiator 8 so the temperature in the radiator return line RR remains at ambient until the main thermostat 5 starts to open.

- 5 The EGR mixer valve 20 could be used in conjunction with other types of auxiliary heat exchanger which require a relatively low coolant temperature, e.g. turbocharger intercoolers.

- Although the EGR mixer valve 20 as described above uses a wax capsule type of thermally-responsive actuator, the actuator could be of some other thermally-responsive type, e.g. those using bi-metallic expansion or vapour pressure. Furthermore, the sensing of temperatures could be done through thermocouples or other temperature sensing means located to sense either the engine return flow only or both the engine return flow and the radiator return flow and the control could be by means of a servo valve, either directly connected to the thermocouples or indirectly through an electronic control unit.
- 10 Sensing the engine return flow only would remove the benefit of ambient compensation but would still retains many of the other benefits over known cooling systems.
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CLAIMS

1. An engine cooling system (10) comprising a primary cooling circuit having a radiator (8) for cooling liquid coolant for the engine (3), a bypass (BL) arranged in parallel with the radiator (8), a pump (2) to circulate the coolant through the engine (3), the radiator (8) and the bypass (BL) and a primary flow control valve (5) to control flow as between the radiator (8) and the bypass (BL), the primary flow control valve (5) being operative to prevent flow through the radiator (8) until the engine (3) has reached an appropriate running temperature, an engine supply line (SL) being arranged to deliver coolant from the pump to the engine, an engine return line (ER) being arranged to deliver coolant from the engine to the bypass (BL) and to the radiator (8), a radiator return line (RR) being arranged to deliver coolant from the radiator (8) to the primary flow control valve (5) and a pump return line (RL) being arranged to deliver coolant from the primary flow control valve (5) to the pump (2), the cooling system (10) also comprising an auxiliaries cooling circuit having an auxiliary heat exchanger (21) arranged so that coolant can flow from the engine return line (ER) and from the radiator return line (RR) through the auxiliary heat exchanger (21) and be returned as an auxiliaries return flow into the pump return line (RL) and a secondary flow control valve (20) having a first inlet (31) connected to the engine return line (ER), a second inlet (32) connected to radiator return line (RR) and an outlet (33) connected to the auxiliary heat exchanger (21), the secondary flow control valve (20) being operative to control flow as between flow from the engine return line (ER) through the first inlet (31) and flow from the radiator return line (RR) through the second inlet (32).
2. A cooling system as claimed in claim 1 in which the secondary flow control valve (20) is operative to prevent flow from the radiator return line (RR) through the second inlet (32) until coolant from the engine return line (ER) in the first inlet (31) reaches a first predetermined temperature.

- 13 -

3. A cooling system as claimed in claim 1 or claim 2 in which the secondary flow control valve (20) is operative to restrict the flow from the engine return line (ER) through the first inlet (31) when the flow through the first inlet (31) exceeds a second predetermined temperature.
4. A cooling system as claimed in claim 1 or claim 2 in which the secondary flow control valve (20) is operative to restrict the flow from the engine return line (ER) through the first inlet (31) when a combination of the temperature of the coolant from the radiator return line (RR) at the second inlet (32) and the temperature of the coolant from the engine return line (ER) at the first inlet (31) exceeds a second predetermined temperature.
5. A cooling system as claimed in claim 3 or in claim 4 in which substantially no flow from the engine return line (ER) is allowed through the first inlet (31) when the temperature of the flow from the engine return line (ER) exceeds the second predetermined temperature.
6. A cooling system as claimed in any preceding claim in which the secondary flow control valve (20) comprises a thermally-responsive actuator (19) having a temperature sensitive portion (21) that is exposed to at least one of the flows through the first inlet (31) and the second inlet (32).
7. A cooling system as claimed in claim 6 when dependent upon claim 2 in which the temperature sensitive portion (21) is exposed to only to coolant from the engine return line (ER) in the first inlet (31) when the coolant in the first inlet is below the first predetermined temperature.
8. A cooling system as claimed in claim 6 when dependent upon claim 2 or as claimed in claim 7 in which the temperature sensitive portion (21) is exposed to both coolant from

- 14 -

the engine return line (ER) in the first inlet (31) and coolant from the radiator return line (RR) in the second inlet (32).

9. A cooling system as claimed in any preceding claim in which the secondary flow control valve (20) comprises a housing (30), the housing defining the first inlet (31), the second inlet (32), the outlet (33) and a valve chamber (41), and a valve assembly (42) mounted in the valve chamber, the valve assembly comprising a valve shuttle (24) and a biasing means (22) to bias the valve shuttle towards a position in which the valve assembly allows flow through the first inlet to the outlet while preventing flow through the second inlet to the outlet.
10. A cooling system as claimed in claim 9 when dependent upon claim 6 in which the valve assembly (42) further comprises the thermally-responsive actuator (19), the thermally-responsive actuator being arranged to urge the valve shuttle (24) against the biasing means (22) to allow flow through the second inlet (32) to the outlet (33) when the coolant from the engine return line ER reaches the first predetermined temperature while continuing to allow the flow from the first inlet (31) through to the outlet.
11. A cooling system as claimed in claim 10 when dependent upon claim 3 or claim 4 in which, with increasing temperature of the flow from the engine return line ER, the valve shuttle (24) moves further against the biasing means (22) to obstruct the flow from the engine return line ER through the first inlet (31) when the second predetermined temperature is attained while continuing to allow flow from the radiator the return line from the second inlet (32) through to the outlet (33).
12. A cooling system as claimed in any of claims 9 to 11 in which the valve shuttle (24) has a main valve member (25) which cooperates with the housing (30) to close the second inlet (32).

- 15 -

13. A cooling system as claimed in claim 12 when dependent upon claim 11 in which the main valve member (25) cooperates with the housing (30) to obstruct the first inlet (31).
14. A cooling system as claimed in any of claims 9 to 13 when dependent upon claim 6 in which the thermally-responsive actuator (19) comprises an actuator body fast with the valve shuttle (24) and a pushrod (18) extending from one end of the actuator body for cooperation with an abutment (29) on the housing (30), the actuator body including said temperature sensitive portion (21).
15. A cooling system as claimed in claim 14 in which the abutment (29) is in the second inlet (32).
16. A cooling system as claimed in any of claims 9 to 15 in which the biasing means is a helical spring (22).
17. A cooling system as claimed in claim 16 in which the helical spring (22) is axially guided by the housing (30).
18. A cooling system as claimed in claim 17 in which the helical spring (22) is located in the first inlet (31).
19. A cooling system as claimed in claim 17 or in claim 18 in which the valve shuttle (24) has a fluted end portion (27) which is engaged within the helical spring (22) so that the valve shuttle (24) is axially guided by the helical spring.
20. A cooling system as claimed in claim 19 in which the fluted end portion comprises elongate fins (27), each fin having a step (26) to form a reaction surface for the helical spring (22, 122, 222).

- 16 -

21. A cooling system as claimed in any of claims 9 to 20 in which a retainer (23) is in the first inlet (31) to form a reaction surface for the biasing means (22).
22. A cooling system as claimed in claim 14 in which the valve shuttle (24) is shaped to allow coolant to directly contact the temperature sensitive portion (21) of the actuator body.
23. A cooling system as claimed in claim 22 when dependent upon claim 12 in which the valve shuttle (24) is shaped to allow coolant to directly contact the temperature sensitive portion (21) of the actuator body on the side of the main valve member (25) towards the first inlet (31) and on the side of the main valve member towards the second inlet (32).
24. A cooling system substantially as described herein with reference to the accompanying drawings.
25. A secondary flow control valve when used in an engine cooling system as claimed in any preceding claim.
26. A secondary flow control valve for use in an engine cooling system as claimed in any of claims 1 to 24 and substantially as described herein with reference to the accompanying drawings.

1/2

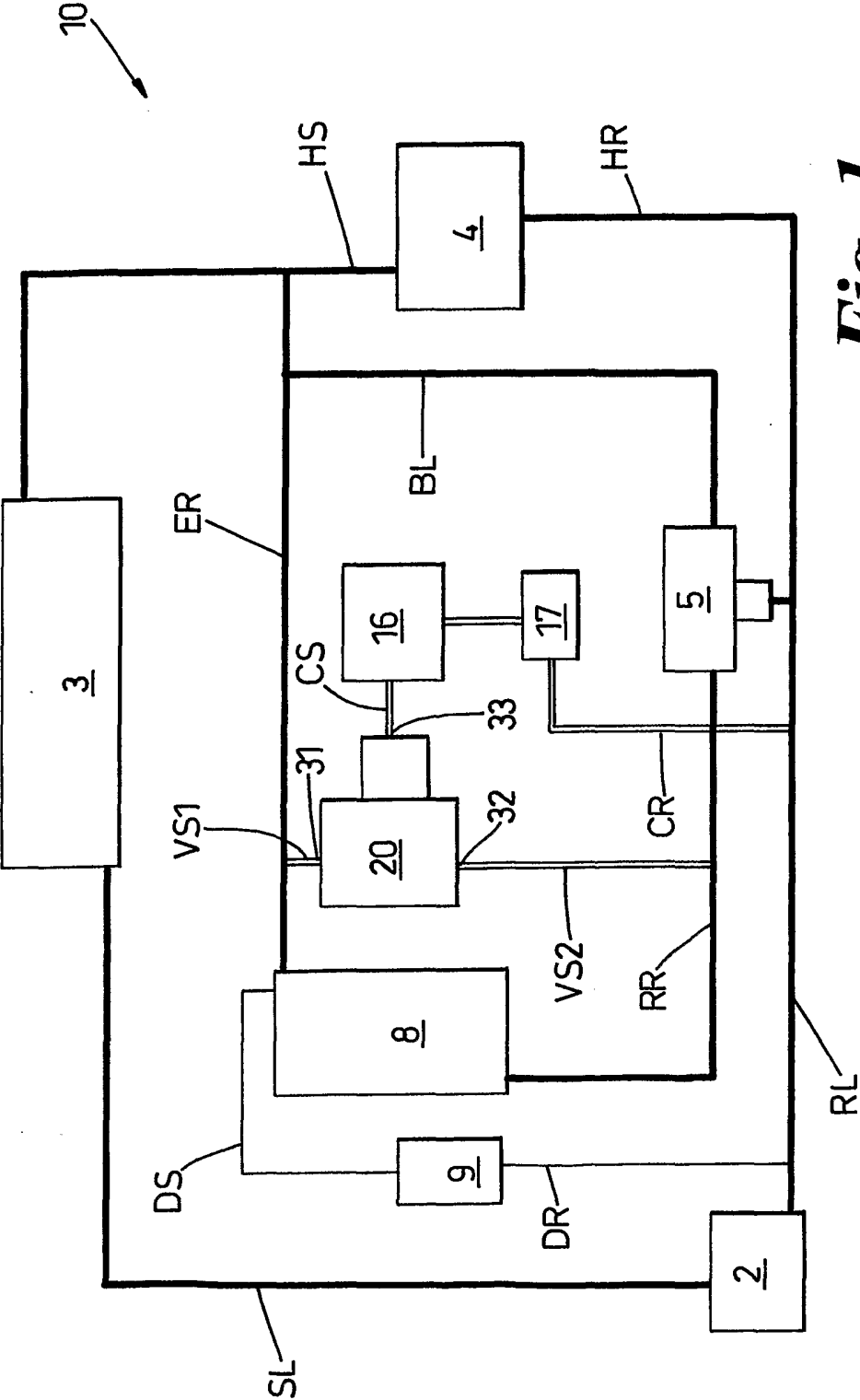
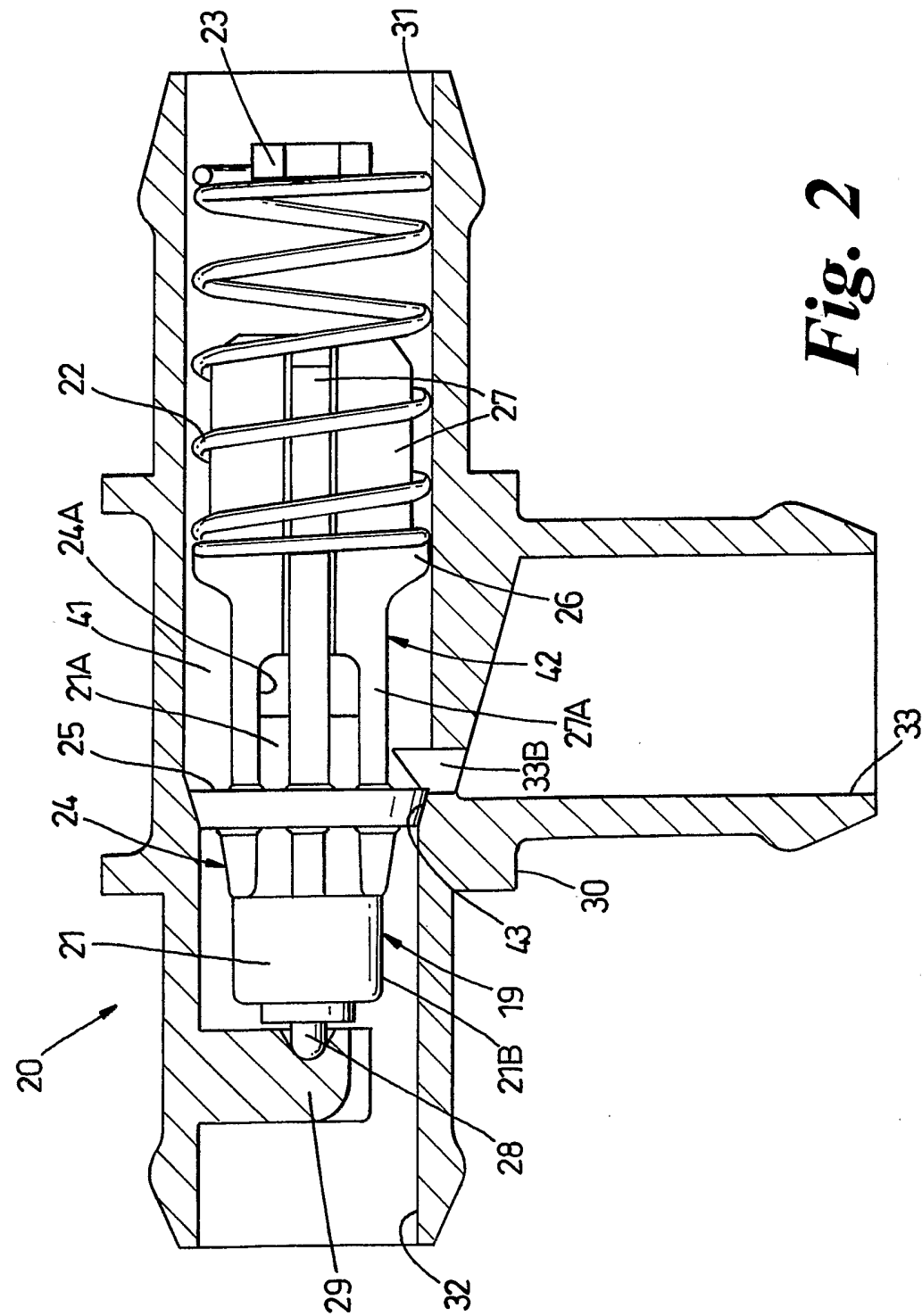


Fig. 1

2/2



INTERNATIONAL SEARCH REPORT

PCT/GB 03/03586

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 F01P7/16

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)

IPC 7 F01P F02M

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

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

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 196 168 B1 (ECKERSKORN ET AL.) 6 March 2001 (2001-03-06) column 3, line 44 - column 4, line 17; figures	1-3,5,6, 24-26
X	EP 0 870 911 A (BMW) 14 October 1998 (1998-10-14) abstract; figure	1-3,5,9, 11-13, 24-26
X	US 4 517 929 A (MUSICK ET AL.) 21 May 1985 (1985-05-21) column 2, line 22 - column 5, line 63; figures	1-3,5,6, 9,24-26
X	EP 1 055 813 A (BMW) 29 November 2000 (2000-11-29) paragraph '0017! - paragraph '0020!; figure	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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04/11/2003

Name and mailing address of the ISA

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INTERNATIONAL SEARCH REPORT

PCT/GB 03/03586

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