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Remarks:
Amended claims in accordance with Rule 137(2) EPC.

(54) Cooling system

(57) A system for cooling exhaust gas for recirculation in an engine comprising a radiator for cooling engine coolant having an upstream water tank with a radiator inlet, a central radiator part and a downstream water tank with a first radiator outlet; a first cooling circuit having an upstream radiator conduit adapted to carry coolant from the engine to the radiator inlet and a downstream radiator conduit adapted to carry coolant from the radiator outlet and to the engine; a bypass conduit connected between the upstream radiator conduit and the downstream radiator conduit adapted to allow coolant to bypass the radiator; a first thermostat controlled valve arranged in the upstream radiator conduit at the engine outlet and connected to the bypass conduit, the first thermostat controlled valve is adapted to direct coolant flow to the radiator and/or to the bypass conduit; an exhaust gas recirculation cooler for cooling exhaust gas comprised in an exhaust gas cooling circuit. The downstream water tank and the central radiator part of the radiator is divided in a sub-cooler part having a second radiator outlet and a main part, wherein the exhaust gas cooling circuit is connected to the sub-cooler part such that it provides coolant to the exhaust gas recirculation cooler.

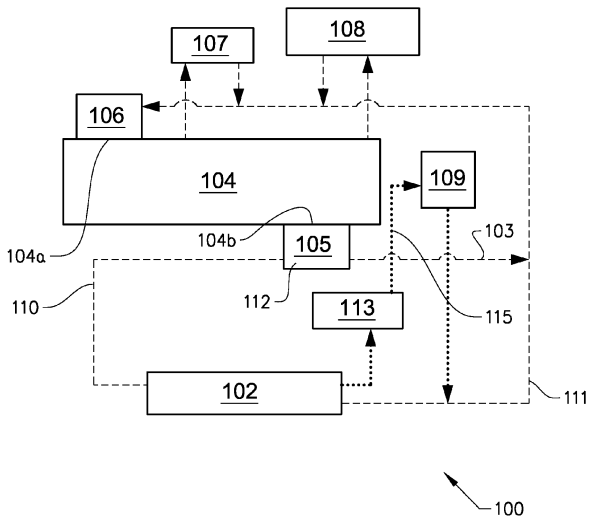

FIG. 3

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of cooling systems, and more particularly, to exhaust gas recirculation (EGR) cooling systems for engines in vehicles.

BACKGROUND

[0002] Today, there exist various examples of EGR cooling systems comprising an EGR cooler in an EGR cooling circuit. The EGR cooler is a heat exchanger installed in an EGR cooling circuit of a vehicle. The EGR cooling system recirculates exhaust gas back to the engine in order to reduce nitrous oxide (NOx) emissions. The EGR cooler, cools the exhaust gas prior to the exhaust gas is being reintroduced into the engine. By cooling the exhaust gas, the combustion temperature is reduced and since NOx emissions are formed at higher temperatures, this result in a reduction of NOx emissions. The EGR cooling systems reduces NOx production by recirculating small amounts of exhaust gases into the intake manifold where it mixes with the incoming air/fuel charge. By diluting the air/fuel mixture under these conditions, peak combustion temperatures and pressure are reduced, resulting in overall reduction of NOx output.

[0003] Today, in EGR cooling systems the EGR cooling circuit takes coolant from a thermostat house, upstream of thermostat controlled valve, i.e. there is always a flow to the EGR cooling circuit independent of the position of the thermostat controlled valve (either closed or more or less open). An open thermostat controlled valve is also called working thermostat controlled valve. Further, since the coolant is taken from thermostat house upstream of the thermostat controlled valve, the coolant temperature to the EGR cooler is always relatively high. Coolant flow is substantially a function of water pump speed. These known EGR cooling systems are restricted to a relatively high coolant temperature being used to supply the EGR cooler. Thereby, the cooling efficiency of the EGR cooler is relatively low.

[0004] Today, there also exist, the concept of super cooled EGR cooling systems comprising an EGR cooler in a super cooled EGR cooling circuit. The main disadvantage with these super cooled EGR cooling systems is that as soon as the thermostat controlled valve opens, coolant of relatively high temperature enters the super cooled EGR cooling circuit. Thereby, the cooling efficiency is low.

[0005] There is thus a need for an improved EGR cooling system removing the above mentioned disadvantages.

DESCRIPTION OF INVENTION

[0006] The present invention relates to the field of cooling systems, such as exhaust gas recirculation (EGR) cooling systems using radiator for vehicles. It is desirable to reduce the exhaust gas temperature as much as possible with low cost and with minimum space requirements.

[0007] The object of the present invention is to suggest an improved and easy to implement EGR cooling system which improves exhaust gas cooling without additional costs or additional heat exchangers or parts for reducing the exhaust gas temperature.

[0008] The present invention is defined by the appended independent claims. Various examples of the invention are set forth by the appended dependent claims as well as by the following description and the accompanying drawings.

[0009] With the above description in mind, then, an aspect of the present invention is to provide an improved solution of regulating and directing the coolant to and from an EGR cooler in the EGR cooling system which seeks to mitigate, alleviate, or eliminate one or more of the above-identified deficiencies in the art and disadvantages singly or in any combination.

[0010] The object of the present invention is to provide a relatively cool coolant to the EGR cooler for all positions of a first thermostat controlled valve. Thereby, the exhaust gas temperature is reduced and the risk of breakdown of the EGR cooler is minimized for all possible positions of a first thermostat controlled valve.

[0011] The object is achieved by the features of claim 1 wherein, a system for cooling exhaust gas for recirculation in an engine comprising a radiator for cooling engine coolant having an upstream water tank with a radiator inlet, a central radiator part and a downstream water tank with a first radiator outlet; a first cooling circuit having an upstream radiator conduit adapted to carry coolant from the engine to the first radiator inlet and a downstream radiator conduit adapted to carry coolant from the radiator outlet and to the engine; a bypass conduit connected between the upstream radiator conduit and the downstream radiator conduit adapted to allow coolant to bypass the radiator; a first thermostat controlled valve arranged in the upstream radiator conduit at the engine outlet and connected to the bypass conduit, the first thermostat controlled valve is adapted to direct coolant flow to the radiator and/or to the bypass conduit; an exhaust gas recirculation cooler for cooling exhaust gas comprised in an exhaust gas cooling circuit; characterised in that the downstream water tank and the central radiator part of the radiator is divided in a sub-cooler part having a second radiator outlet and a main part, wherein the exhaust gas cooling circuit is connected to the sub-cooler part such that it provides coolant to the exhaust gas recirculation cooler. Thereby, the inventive EGR cooling system improves exhaust gas cooling efficiency without additional heat exchangers or parts. The inventive EGR cooling system provides coolant, via the radiator, at a low temperature to the EGR cooler. No additional parts or space are required in the inventive cooling system in order to reduce the exhaust gas temperature.

[0012] According to the invention, coolant to the exhaust gas recirculation cooler is provided from the radiator regardless of the position of the first thermostat controlled valve. Thereby, relatively cool coolant is always provided to the EGR cooler via the radiator and no additional heat exchangers are needed to reduce the exhaust gas temperature.

[0013] The inventive EGR cooling system, regardless of the position of the first thermostat controlled valve, always provides relatively cool coolant to the EGR cooler. Thereby, the inventive EGR cooling system allow for an EGR cooler with reduced space requirements, while still being able to improve or maintain the cooling efficiency of the EGR cooling system.

[0014] According to the invention, the system further comprises an electrical water pump arranged in the exhaust gas cooling circuit between the sub-cooler part and the exhaust gas recirculation cooler providing a coolant flow through the exhaust gas recirculation cooler and the radiator.

[0015] According to the invention, the exhaust gas recirculation cooler is arranged in the exhaust gas cooling circuit between the electrical water pump and the downstream radiator conduit.

[0016] According to the invention, the relation between the amount of radiator pipes in the sub-cooler part and in the main part of the central part of the radiator of the may be varied.

[0017] According to the invention, the first thermostat controlled valve regulates and directs the coolant to the bypass when the coolant from the engine is below a threshold level. According to the invention, the first thermostat controlled valve regulates and directs coolant to the radiator when the coolant from the engine is above a threshold level. The threshold value may be varied.

[0018] According to the invention, the system further comprises a transmission oil cooler arranged in a transmission oil cooling circuit and a second thermostat controlled valve arranged between the transmission oil cooling circuit and the exhaust gas cooling circuit for directing coolant flow to the transmission oil cooling circuit or to the exhaust gas cooling circuit. Thereby, the coolant flow may be regulated and directed between the transmission oil cooling circuit and the exhaust gas cooling circuit.

[0019] According to the invention, the transmission oil cooler is arranged in the transmission oil cooling circuit between the second thermostat controlled valve and the downstream radiator conduit.

[0020] According to the invention, the transmission oil cooler is connected in parallel with the exhaust gas recirculation cooler.

[0021] According to the invention, the second thermostat controlled valve regulates and directs the coolant flow to the transmission oil circuit at high load and high speed.

[0022] According to the invention, the second thermostat controlled valve regulates and directs the coolant flow to the exhaust gas recirculation circuit at low and low speed.

[0023] Any of the advantageous features of the present invention above may be combined in any suitable way.

[0024] A number of advantages are provided by means of the present invention, for example:

- a radiator for both manual and automatic transmission vehicles with reduction in parts and cost is obtained;
- an improved cooling efficiency is obtained;
- a relatively cool coolant is provided to the EGR cooler for all positions of the first thermostat controlled valve;
- simplified installation and maintenance is allowed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] The present invention will now be described in detail with reference to the figures, wherein:

Fig. 1 schematically shows a pictorial representation of an engine cooling having a known EGR cooling system.

Fig. 2 schematically shows a pictorial representation of an engine having a known super cooled EGR cooling system.

Fig. 3 schematically shows a pictorial representation of an engine having an EGR cooling system according to the invention for vehicles with manual transmission.

Fig. 4 schematically shows a front view pictorial representation of an EGR cooling system according to the invention for vehicles with manual transmission.

Fig. 5 schematically shows a front view pictorial representation of an EGR cooling system according to the invention for vehicles with manual transmission having a closed first thermostat controlled valve.

Fig. 6 schematically shows a front view pictorial representation of an EGR cooling system according to the invention for vehicles with manual transmission having a working first thermostat controlled valve.

Fig. 7 schematically shows a front view pictorial representation of an EGR cooling system according to the invention for vehicles with automatic transmission.

[0026] It should be added that the following description of the examples is for illustration purposes only and should not be interpreted as limiting the invention exclu-

sively to these examples/aspects.

DETAILED DESCRIPTION

[0027] All the figures 1 to 7 are schematically illustrated.

[0028] Figure 1 refers to prior art and schematically shows an engine having an EGR cooling system. The EGR cooling system comprises an EGR cooler 9 in an EGR cooling circuit. The dotted lines and arrows represent the coolant circuits and flows to and from the engine where the EGR cooling circuit is marked in bold dotted lines. Figure 1 shows an engine 4 having an engine inlet 4a and engine outlet 4b, a water pump 6, an engine oil cooler 7, a cabin heater 8, an exhaust gas recirculation cooler 9, a bypass conduit 3, a thermostat house 5 comprising a first thermostat controlled valve 12, an upstream radiator conduit 10, a radiator 2 and a downstream radiator conduit 11. The EGR cooling circuit takes coolant from a thermostat house 5, upstream of the thermostat controlled valve 12, i.e. there is always a flow to the EGR cooling circuit independent of the position of the thermostat controlled valve 12 (either closed or more or less open). Further, since the coolant is taken from the thermostat house 5 upstream, of the first thermostat controlled valve 12, the coolant temperature to the EGR cooler 9 is always relatively high. Hot engine water is supplied to the EGR cooler. Coolant flow is substantially a function of water pump speed. Due to that a relatively high coolant temperature is used to supply the EGR cooler 9, the cooling efficiency of the EGR cooler is relatively low.

[0029] To this problem with the a high coolant temperature being supplied to the EGR cooler 9, the concept of super cooled EGR cooling systems was invented in the automotive industry.

[0030] Figure 2 refers to prior art and schematically shows an engine having an EGR cooling system. The dotted lines and arrows represent the coolant circuits and flows to and from the engine 4 where a super cooled EGR cooling circuit is marked in bold lines. The super cooled EGR cooling system comprises an electrical water pump 13 and an EGR cooler 9 in an EGR cooling circuit. When the thermostat is closed, i.e. closed thermostat controlled valve 12, coolant flow only in the bypass conduit 3 and no coolant flow in upstream radiator conduit 10. An electrical water pump (EWP) 13 is used to create a flow through the EGR cooler 9 and the radiator 2, and since the radiator 2 is used in the super cooled EGR cooling circuit a relatively low coolant temperature is obtained for the EGR cooler 9 when the thermostat controlled vale 12 is closed.

[0031] Figure 2 shows a super cooled EGR cooling system for a working thermostat, i.e. open thermostat controlled valve 12, (i.e. coolant temperature has reached the thermostat opening temperature or higher) having a clockwise coolant flow.

[0032] During a clockwise flow direction the coolant to the super cooled EGR cooling circuit is taken from the upstream radiator conduit 10. When the thermostat controlled valve 12 is open there is a flow out to the upstream radiator conduit 10. Depending on the position of the thermostat controlled valve 12, coolant pressure and flow in the upstream radiator conduit 10 are different, wherein a small opening for the thermostat controlled valve 12, equals a small flow in the upstream radiator conduit 10 and a larger opening for the thermostat controlled valve 12, equals a larger flow in the upstream radiator conduit 10. The EWP power creates a flow in clockwise direction and the resulting mixed flow in to the super cooled EGR cooling circuit has an increase in coolant temperature compared to the coolant temperature from the radiator 2 (the mixed flow consist of hot water from engine via upstream radiator conduit 10 and from the radiator 2). Thus, the main disadvantage is that as soon as the thermostat controlled valve 12 is in an open position, coolant of relatively high temperature enters the super cooled EGR cooling circuit. Thereby, hot engine water enters the super cooled EGR cooling circuit resulting in reduced cooling efficiency.

[0033] The following examples of the present invention relate, in general, to the field of cooling systems, in particularly, to EGR cooling systems using a radiator for vehicles for providing relatively cool coolant for all positions of the thermostat controlled valve 12, i.e. thermostat strokes.

[0034] Examples of the present invention will be described more fully hereinafter with reference to the accompanying drawings, in which examples of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the examples set forth herein. Rather, these examples are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like reference signs refer to like elements throughout.

[0035] Figure 3 shows an example of an engine having an EGR cooling system 100 according to the invention for vehicles with manual transmission. The dotted lines and arrows represent the coolant circuits and flows to and from an engine 104 where an EGR cooling circuit 115 is marked in bold lines. The engine 104 includes an engine inlet 104a where coolant enters the engine 104 and an engine outlet 104b where coolant leaves the engine. Figure 3 shows a water pump 106, an engine oil cooler 107, a cabin heater 108, a bypass conduit 103, a thermostat house 105 comprising a first thermostat controlled valve 112, an upstream radiator conduit 110, a radiator 102, a downstream radiator conduit 111, a EWP 113 and an EGR cooler 109. The EWP 113 is arranged in the EGR cooling circuit 115. The EWP 113 is adapted to be able to circulate coolant through the EGR cooling circuit 115. The inventive EGR cooling circuit 115 is provided with coolant via the radiator 102. The radiator 102 in the inventive EGR cooling system 100 is adapted to provide relatively cool coolant to the EGR cooler 109 for all possible positions of the first thermostat controlled

valve 112. The EGR cooler 109 is arranged in parallel to the engine 104.

[0036] The EGR cooler 109 cools the exhaust gas by heat exchange with coolant from the engine cooling system, the coolant passes the radiator 102 before being supplied to the EGR cooler 109. In accordance with the invention, coolant for EGR cooler 109 is circulated in the EGR cooling circuit 115 which is separate from a first cooling circuit, i.e. the engine cooling circuit, but uses the same radiator 102.

[0037] Figure 4 shows an example of the EGR cooling system 100 according to the invention for vehicles with manual transmission where the radiator 102 with an upstream water tank 119 and a downstream water tank 121 are viewed from the front. The radiator 102 comprises a central radiator part 116, the upstream water tank 119, the downstream water tank 121, a radiator inlet 120, a first radiator outlet 122a and a second radiator outlet 122b. The downstream water tank 121 is divided in two chambers providing a sub-cooler part 117 and main part 118, wherein relatively cool coolant is provided to the EGR cooler 109 at all positions of the first thermostat controlled valve 112. The downstream water tank 121 is divided by a divider 123 which divides the downstream water tank 121 into an upper downstream part 121 a and a lower downstream part 121 b. The upper downstream part 121 a has a second radiator outlet 122b. The lower downstream part 121 b has a first radiator outlet 122a.

[0038] The sub-cooler part 117 comprises the upper downstream part 121 a of the downstream tank 121 and the upper part of the central radiator part 116. The main part 118 comprises the lower downstream part 121 b of the downstream water tank 121 and the lower part of the central radiator part 116. The connection for the EGR cooling circuit 115 is connected to the sub-cooler part 117 of the downstream tank 121. Whereby, coolant always flows via the radiator 102 before being supplied the EGR cooler 109. This advantageously allows for cooler exhaust gas, which may be used more effectively in the EGR cooling system 100. The divider 123 is preferably made from a light plastic material. The divider 123 and the downstream water tank 121 are preferably of the same material. However, the divider 123 may be made of any suitable material. The position of the divider 123 may be adapted to be adjustable within the downstream water tank 121.

[0039] Figure 4 show an upstream radiator conduit flow 124 where coolant flow in the upstream radiator conduit from the first thermostat controlled valve, a downstream radiator conduit flow 125 where coolant flow in the downstream radiator conduit from the EGR cooler 109 and the main part 118 and a water pump flow 126 where coolant flow towards a water pump 106.

[0040] Fig. 5 schematically shows a front view pictorial representation of an EGR cooling system 100 according to the invention for vehicles with manual transmission when the first thermostat controlled valve 112 is closed. When the first thermostat controlled valve 112 is in a closed position a first coolant flow 127 circulate in the radiator 102 as shown in figure 5. This circulating first coolant flow 127 flows through the upstream water tank 119 to the sub-cooler part 117, out from the radiator 102 via the second radiator outlet 122b through the EWP 113, through the EGR cooler 109, through the downstream radiator conduit 111 and the main part 118 of the radiator 102 via the first radiator outlet 122a and back to the upstream water tank 119. The flow direction through the sub-cooler 117 is opposite of the flow direction through the main part 118.

[0041] Fig. 6 schematically shows a front view pictorial representation of an EGR cooling system 100 according to the invention for vehicles with manual transmission when the working first thermostat controlled valve is open. When the first thermostat controlled valve 112 is in an open position a second coolant flow 128 flows in the radiator 102 as shown in figure 6. When the first thermostat controlled valve 112 is open the upstream radiator conduit flow 124 flows in the upstream radiator conduit 110 through the radiator inlet 120 into the upstream water tank 119 of the radiator 102, wherein the second coolant flow 128 have the same flow direction through both the sub-cooler part 117 and the main part 118.

[0042] The inventive EGR cooling system 100 provides a relatively cool coolant to the EGR cooler 109 even when the flow pressure is such that the EWP 113 power is not enough to circulate the coolant. This since coolant always flows via the radiator 102 to the EGR cooling circuit 115 and the EGR cooler 109 regardless of the position of the first thermostat controlled valve 112.

[0043] For both a closed and open first thermostat controlled valve 112, it is always relatively cool coolant that is supplying the EGR cooler 109 in the inventive EGR cooling circuit 115. This since coolant is always taken from the downstream water tank 121. The inventive EGR cooling system 100 provide a continuous coolant flow through the EGR cooler 109.

[0044] Fig. 7 schematically shows a front view pictorial representation of an EGR cooling system 100 according to the invention for vehicles with automatic transmission.

[0045] Vehicles with automatic transmission normally need a transmission oil cooler 130 in cooling performance driving conditions. The requirement of cooling the transmission oil cooler 130 and the EGR cooler 109 do not occur at the same time. Referring to figure 7, the EGR cooling circuit with the EWP 113 is used i.e. coolant flow through the EGR cooling circuit, for a vehicle with low load and low speed. The transmission oil cooling circuit with the transmission oil cooler 130 is used, i.e. coolant flow through the transmission oil cooling circuit, at high load and high speed. By using a second thermostat controlled valve 129 or an electric valve, it is possible to move the coolant flow between the EGR cooling circuit and the transmission oil cooling circuit. The opening temperature of this second thermostat controlled valve 129 may be set at a higher temperature than the first thermostat controlled valve 112. The EGR cooler 109 is arranged in

parallel to the transmission oil cooler 130 and to the second thermostat controlled valve 129. The position of the divider 123 may be adjusted if the coolant flow to the transmission oil cooler needs to be adjusted.

[0046] The position of the divider 123 determines to the amount of radiator pipes in the sub-cooler part 117 and the main part 118 of the central part 116 of the radiator 102. The amount of radiator pipes in the radiator 102 for the sub-cooler part 117 may be selected depending on the coolant flow demand to the transmission oil cooler 130.

[0047] The EGR cooling system 100 according to the invention may be used for any type of appropriate engine in any type appropriate vehicle in the form of, for example, a car, a truck, a bus or other vehicle using radiator 102.

[0048] The invention is not limited to the example described above, but may be modified without departing from the scope of the claims below. .

[0049] The terminology used herein is for the purpose of describing particular examples only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" "comprising," "includes" and/or "including" when used herein, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof..

[0050] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. It will be further understood that terms used herein should be interpreted as having a meaning that is consistent with their meaning in the context of this specification and the relevant art and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein..

[0051] The foregoing has described the principles, preferred examples and modes of operation of the present invention. However, the invention should be regarded as illustrative rather than restrictive, and not as being limited to the particular examples discussed above. The different features of the various examples of the invention can be combined in other combinations than those explicitly described. It should therefore be appreciated that variations may be made in those examples by those skilled in the art without departing from the scope of the present invention as defined by the following claims.

REFERENCE SIGNS

[0052]

2: Radiator

3: Bypass conduit

4: Engine

4a: Engine inlet

4b: Engine outlet

5: Thermostat house

6: Water pump

7: Engine oil cooler

8: Cabin heater

9: Exhaust gas recirculation cooler (EGR)

10: Upstream radiator conduit

11: Downstream radiator conduit

12: First thermostat controlled valve

13: Electrical water pump (EWP)

100: Exhaust gas recirculation cooling system

102: Radiator

103: Bypass conduit

104: Engine

104a: Engine inlet

104b: Engine outlet

105: Thermostat house

106: Water pump

107: Engine oil cooler

108: Cabin heater

109: Exhaust gas recirculation cooler (EGR)

110: Upstream radiator conduit

111: Downstream radiator conduit

112: First thermostat controlled valve

113: Electrical water pump (EWP)

115: Exhaust gas recirculation cooling circuit

116: Central radiator part

117: Sub-cooler part

118: Main part

119: Upstream water tank

120: Radiator inlet

121: Downstream water tank

121 a: Upper downstream part

121 b: Lower downstream part

122a: First radiator outlet

122b: Second radiator outlet

123: Divider

124: Upstream radiator conduit flow

125: Downstream radiator conduit flow

126: Water pump flow

127: First coolant flow

128: Second coolant flow

129: Second thermostat controlled valve

130: Transmission oil cooler

Claims

1. A system (100) for cooling exhaust gas for recirculation in an engine comprising:

a radiator (102) for cooling engine coolant having an upstream water tank (119) with a radiator inlet (120), a central radiator part (116) and a downstream water tank (121) with a first radiator outlet (122a);
a first cooling circuit having an upstream radiator conduit (110) adapted to carry coolant from the engine (104) to the radiator inlet (120) and a downstream radiator conduit (111) adapted to carry coolant from the radiator outlet (122) and to the engine (104);
a bypass conduit (103) connected between the upstream radiator conduit (110) and the downstream radiator conduit (111) adapted to allow coolant to bypass the radiator (102);
a first thermostat controlled valve (112) arranged in the upstream radiator conduit (110) at the engine outlet (1 04b) and connected to the bypass conduit (103), the first thermostat controlled valve (112) is adapted to direct coolant flow to the radiator (102) and/or to the bypass conduit (103);
an exhaust gas recirculation cooler (109) for cooling exhaust gas comprised in an exhaust gas cooling circuit;
characterised in that the downstream water tank (121) and the central radiator part (116) of the radiator (102) is divided in a sub-cooler part (117) having a second radiator outlet (122b) and a main part (118), wherein the exhaust gas cooling circuit is connected to the sub-cooler part (117) such that it provides coolant to the exhaust gas recirculation cooler (109).

2. The system (100) according to claim 1, **characterised in that** coolant to the exhaust gas recirculation cooler (109) is provided from the radiator (102) regardless of the position of the first thermostat controlled valve (112).

3. The system (100) according to any of the previous claims, **characterised in that** the system further comprises an electrical water pump (113) arranged in the exhaust gas cooling circuit between the sub-cooler part (117) and the exhaust gas recirculation cooler (109) providing a coolant flow through the exhaust gas recirculation cooler (109) and the radiator (102).

4. The system (100) according to claim 3, **characterised in that** the exhaust gas recirculation cooler (109) is arranged in the exhaust gas cooling circuit between the electrical water pump (113) and the downstream radiator conduit (111).

5. The system (100) according to any the previous claims, **characterised in that** the system further comprises a transmission oil cooler (130) arranged in a transmission oil cooling circuit and a second thermostat controlled valve (129) arranged between the transmission oil cooling circuit and the exhaust gas cooling circuit for directing coolant flow to the transmission oil cooling circuit or to the exhaust gas cooling circuit.

6. The system (100) according to claim 6, **characterised in that** the transmission oil cooler (130) is arranged in the transmission oil cooling circuit between the second thermostat controlled valve (129) and the downstream radiator conduit (111).

7. The system (100) according to any one of the claims 5 - 6, **characterised in that** the transmission oil cooler (130) is connected in parallel with the exhaust gas recirculation cooler (19).

8. The system (100) according to any one of the claims 5 - 7, **characterised in that** the second thermostat controlled valve (129) regulates and directs the coolant flow to the transmission oil circuit at high load and high speed.

9. The system (100) according to any one of the claims 5 - 7, **characterised in that** the second thermostat controlled valve (129) regulates and directs the coolant flow to the exhaust gas recirculation circuit at low load and low speed.

10. Vehicle comprising a system according to claim 1.

Amended claims in accordance with Rule 137(2) EPC.

1. A system (100) for cooling exhaust gas for recirculation in an engine comprising:

a radiator (102) for cooling engine coolant having an upstream water tank (119) with a radiator inlet (120), a central radiator part (116) and a downstream water tank (121) with a first radiator outlet (122a);
a first cooling circuit having an upstream radiator conduit (110) adapted to carry coolant from the engine (104) to the radiator inlet (120) and a downstream radiator conduit (111) adapted to carry coolant from the radiator outlet (122) and to the engine (104);
a bypass conduit (103) connected between the upstream radiator conduit (110) and the downstream radiator conduit (111) adapted to allow coolant to bypass the radiator (102);
a first thermostat controlled valve (112) arranged in the upstream radiator conduit (110) at the engine outlet (104b) and connected to the bypass conduit (103), the first thermostat controlled valve (112) is adapted to direct coolant flow to the radiator (102) and/or to the bypass conduit (103);
an exhaust gas recirculation cooler (109) for cooling exhaust gas comprised in an exhaust gas cooling circuit;
characterised in that the downstream water tank (121) and the central radiator part (116) of the radiator (102) is divided in a sub-cooler part (117) having a second radiator outlet (122b) and a main part (118), wherein the exhaust gas cooling circuit is connected to the sub-cooler part (117) such that it provides coolant to the exhaust gas recirculation cooler (109), wherein the system further comprises a transmission oil cooler (130) arranged in a transmission oil cooling circuit and a second thermostat controlled valve (129) arranged between the transmission oil cooling circuit and the exhaust gas cooling circuit for directing coolant flow to the transmission oil cooling circuit or to the exhaust gas cooling circuit, wherein the transmission oil cooler (130) is arranged in the transmission oil cooling circuit between the second thermostat controlled valve (129) and the downstream radiator conduit (111), wherein the transmission oil cooler (130) is connected in parallel with the exhaust gas recirculation cooler (19), wherein the second thermostat controlled valve (129) regulates and directs the coolant flow to the transmission oil circuit at high load and high speed, wherein the second thermostat controlled valve (129) regulates and directs the coolant flow to the exhaust gas recirculation circuit at low load and low speed.

2. The system (100) according to claim 1, **characterised in that** coolant to the exhaust gas recirculation cooler (109) is provided from the radiator (102) regardless of the position of the first thermostat controlled valve (112).

3. The system (100) according to any of the previous claims, **characterised in that** the system further comprises an electrical water pump (113) arranged in the exhaust gas cooling circuit between the sub-cooler part (117) and the exhaust gas recirculation cooler (109) providing a coolant flow through the exhaust gas recirculation cooler (109) and the radiator (102).

4. The system (100) according to claim 3, **characterised in that** the exhaust gas recirculation cooler (109) is arranged in the exhaust gas cooling circuit between the electrical water pump (113) and the downstream radiator conduit (111).

5. Vehicle comprising a system according to claim 1.

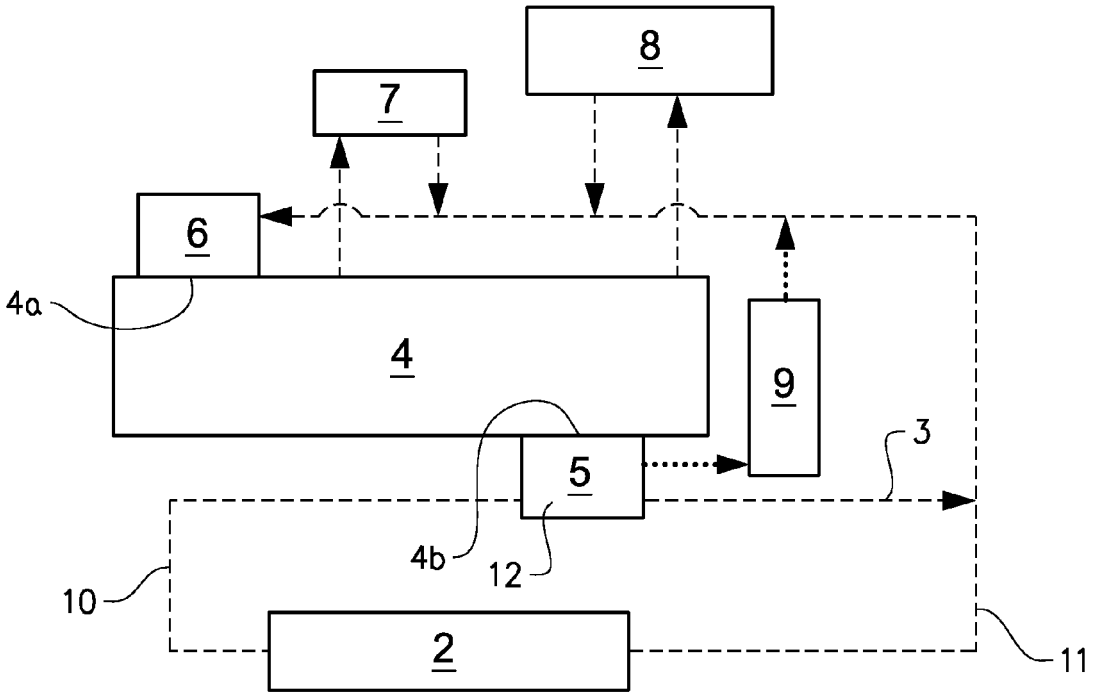


FIG. 1 PRIOR ART

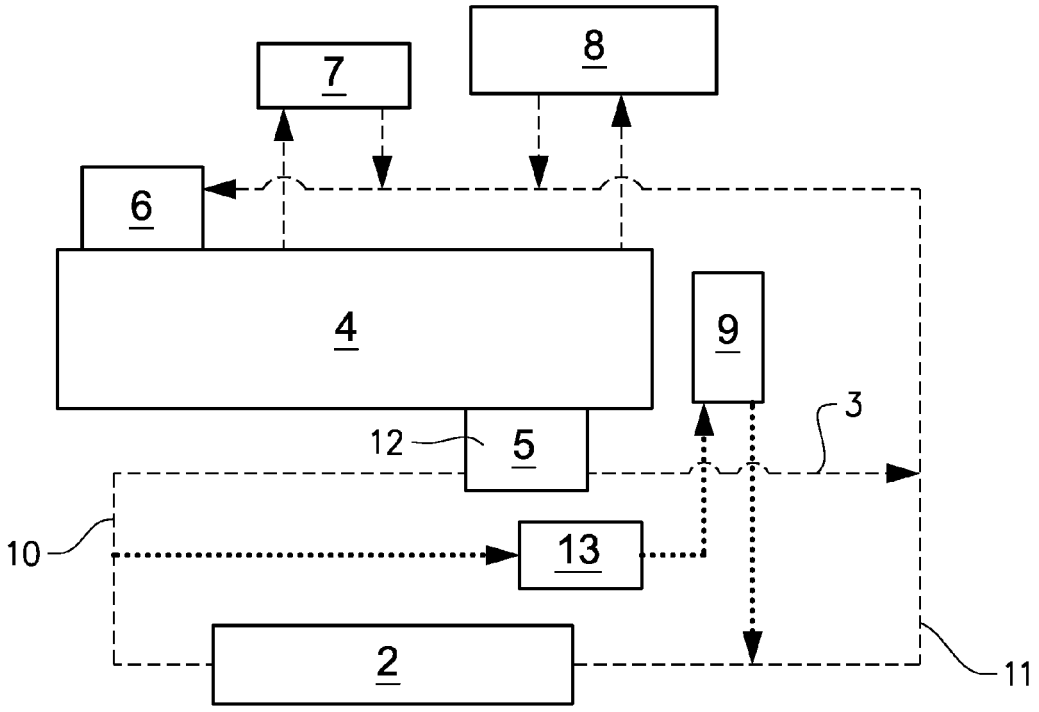


FIG. 2 PRIOR ART

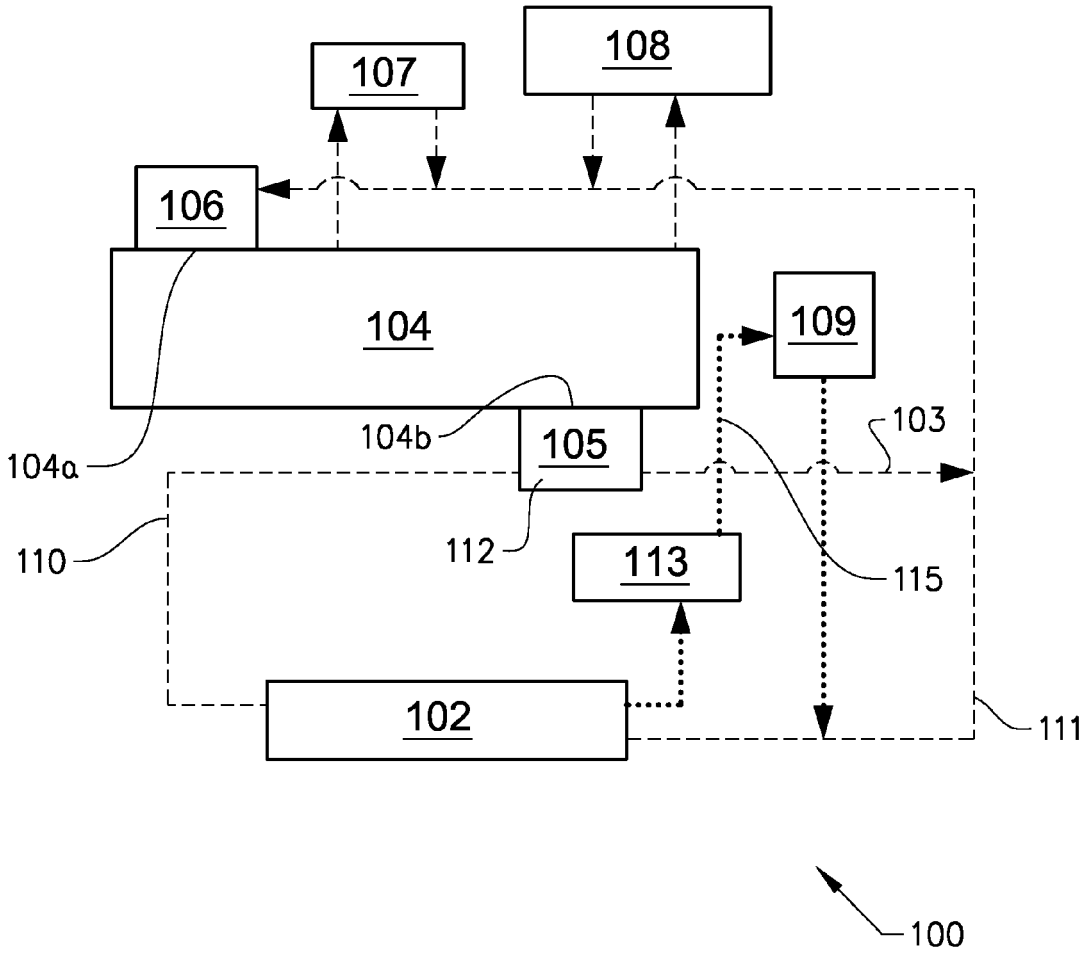
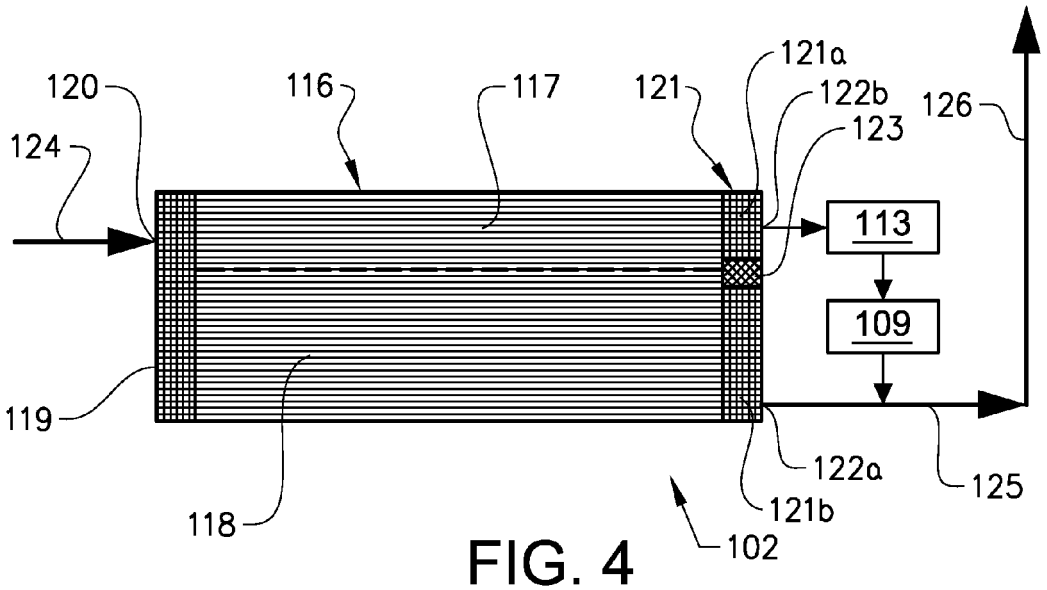

107
108
106
104
109
104a
104b
105
103
110
112
113
115
102
111
100

FIG. 3


120
116
117
121
121a
122b
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126
124
113
109
119
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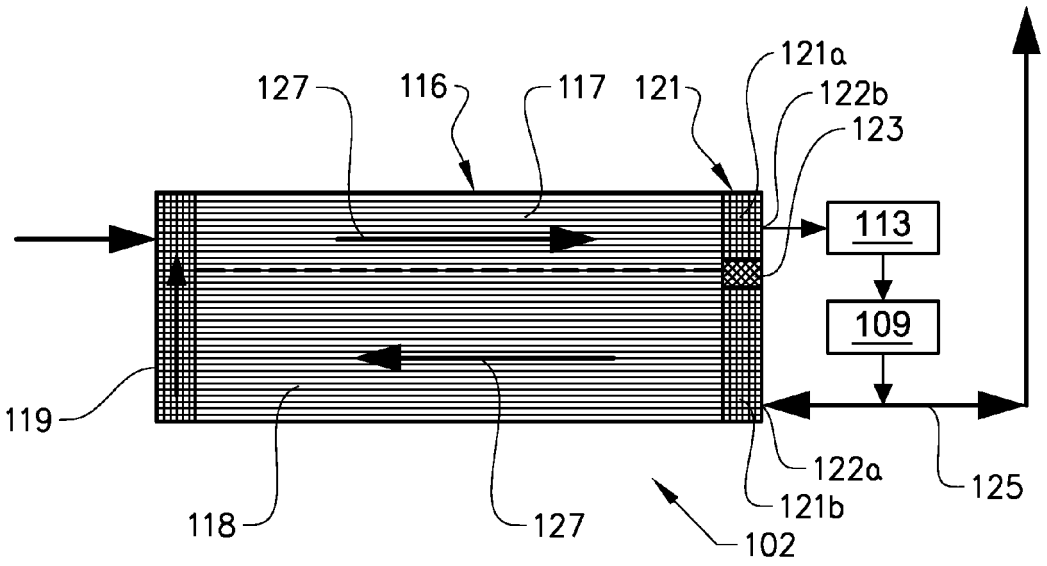
122a
125
121b
102

FIG. 4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121a
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122a
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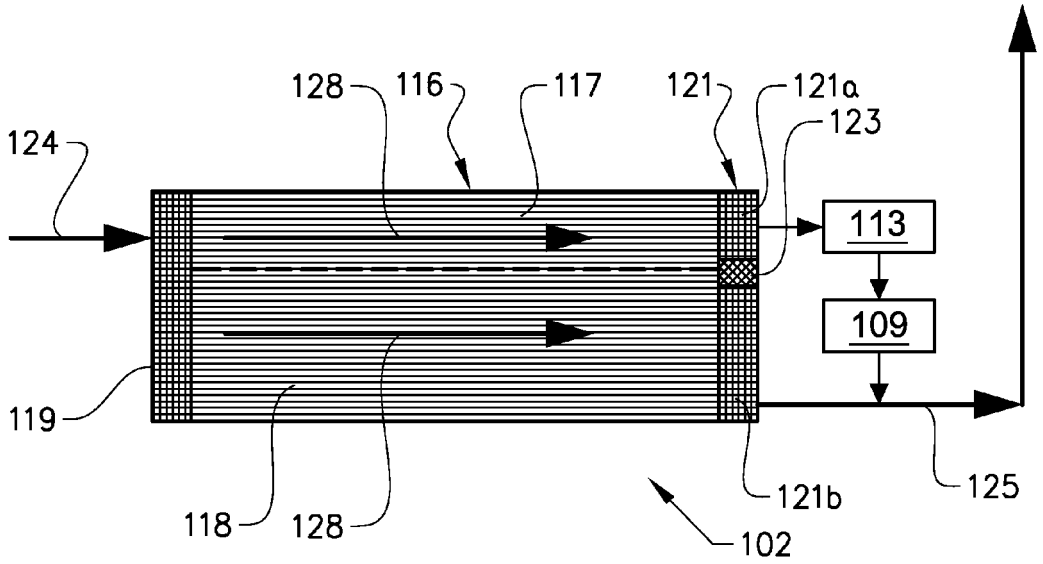
121b
102

FIG. 5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121a
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121b
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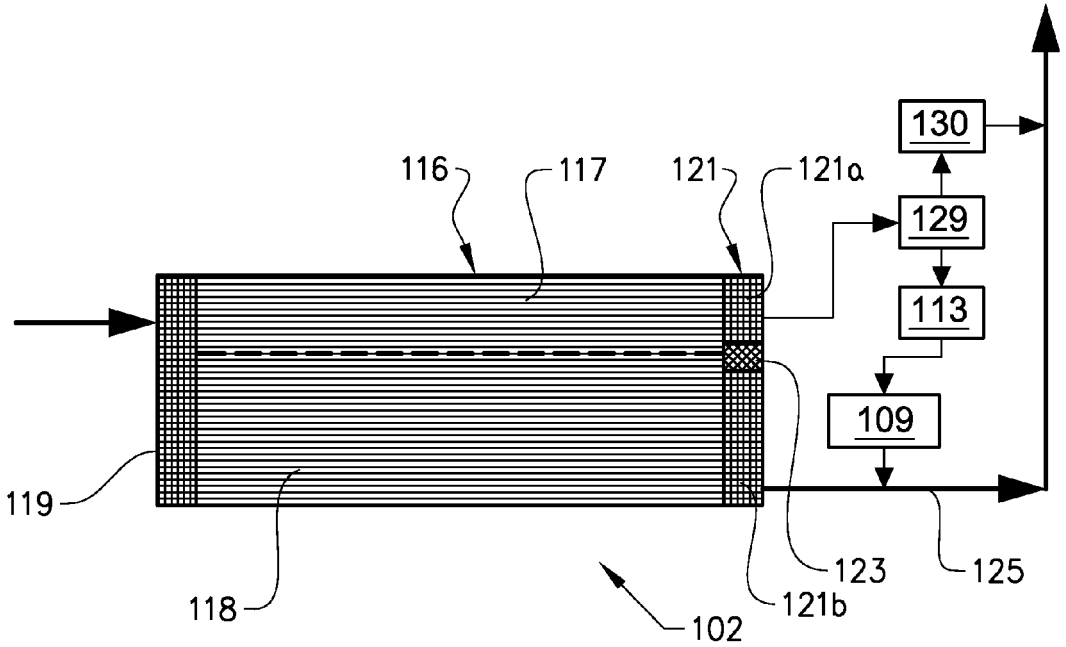
FIG. 6


130
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121
121a
129
113
109
119
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125
118
121b
102

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 11 15 9335

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Place of search	Date of completion of the search	Examiner
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