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(54) Title: COOLING SYSTEM FOR A COMBUSTION ENGINE

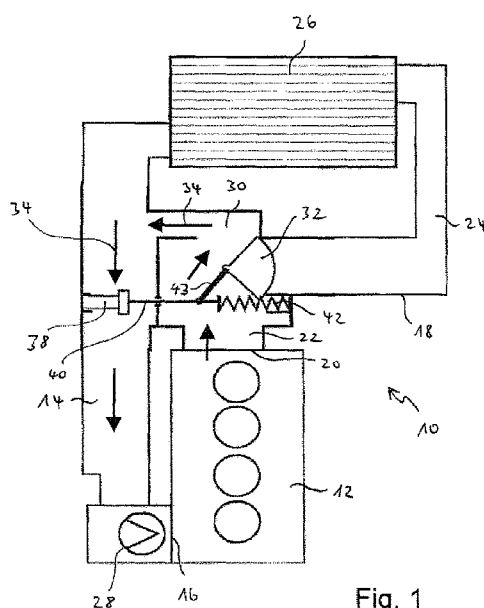


Fig. 1

(57) Abstract: The invention relates to a cooling system for a combustion engine, comprising an inlet for cooling fluid, which is connectable to cooling channels of the combustion engine, and an outlet for cooling fluid, which is also connectable to the cooling channels of the combustion engine, a pump for pumping the cooling fluid through the inlet and outlet, a cooler for cooling the cooling fluid, which is connected to the outlet, on the one hand, and the inlet, on the other hand, and a bypass line, which connects the outlet to the inlet without passing through the cooler, and a valve assembly comprising a valve element and an actuation device for actuating the valve element, characterized in that the valve element is arranged in the outlet and comprises at least three fluid connections, wherein a first fluid connection is connected to a section of the outlet coming from a cooling fluid discharge of the combustion engine, a second fluid connection is connected to a section of the outlet leading to the cooler and a third fluid connection is connected to the bypass line leading to the inlet, and the actuation device comprises an expansion element, which is arranged in the inlet downstream of the connection of the bypass line to the inlet, and with which expansion element the valve element is actuatable such that the first fluid connection is connected to the second and/or third fluid connection.



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COOLING SYSTEM FOR A COMBUSTION ENGINE

The invention relates to a cooling system for a combustion engine, comprising an inlet for cooling fluid, which is connectable to cooling channels of the combustion engine, and an outlet for cooling fluid, which is also connectable to the cooling channels of the combustion engine, a pump for pumping the cooling fluid through the inlet and outlet, a cooler for cooling the cooling fluid, which is connected to the outlet on the one hand and the inlet on the other hand, and a bypass line, which connects the outlet to the inlet without passing through the cooler, and a valve assembly comprising a valve element and an actuation device for actuating the valve element.

In cooling systems of this kind, a pump pumps the coolant, e.g. a water/glycol mixture, via the engine block and the cylinder head of the combustion engine and then via a cooler back into the engine block and cylinder head. Another known practice in this context is to provide a bypass line, by means of which the cooling fluid coming from the engine block and/or cylinder block in the cold starting phase of the engine is passed directly back into the inlet to the engine block and/or cylinder head without passing through the cooler. A cooling system of this kind is known from DE 103 51 852 A1, for example. In this arrangement, a valve assembly comprising a valve element and an actuation device is provided on the discharge side of the combustion engine. The individual flows of cooling fluid can be divided up in the desired manner with just one valve assembly through appropriate actuation of the valve element. An expansion element arranged within the valve ball of a valve element designed as a ball valve, for example, can be provided for the actuation of the valve element, for example. The expansion element is in heat conducting contact with the cooling fluid and expands and contracts with heating and cooling, and in this way automatically actuates the valve element as a thermostat.

One disadvantage of the position of the valve assembly on the discharge side is that the expansion element is exposed to a change in the temperature of the cooling fluid and hence the thermostatic regulation effected by the expansion element takes effect only when the cooling fluid has already flowed through the engine block and the cylinder block. Regulation is therefore subject to a delay and the cold starting phase of the combustion engine is extended in an undesirable way. Another known practice is to arrange valve assemblies of this kind on the side on which cooling fluid is admitted. However, the disadvantage with such an arrangement is that the cooler and, in particular, the cooling hoses are immediately subjected to the full pressure of the cooling fluid when the engine is cold started. This can lead to damage in the cooling hoses, especially in the winter months.

Taking as a starting point the prior art that has been explained, it is the underlying object of the invention to provide a cooling system of the type stated at the outset which, on the one hand, allows rapid regulation and, on the other hand, reliably prevents damage to the cooling system.

The invention achieves this object through the subject matter of claim 1. Advantageous embodiments can be found in the dependent claims, the description and the figures.

For a cooling system of the type stated at the outset, the invention achieves the object by virtue of the fact that the valve element is arranged in the outlet and comprises at least three fluid connections, wherein a first fluid connection is connected to a section of the outlet coming from a cooling fluid discharge of the combustion engine, a second fluid connection is connected to a section of the outlet leading to the cooler and a third fluid connection is connected to the bypass line leading to the inlet, and that the actuation device comprises an expansion element, which is arranged in the inlet downstream of the connection of the bypass line to the inlet, and with which expansion element the valve element is

actuatable such that the first fluid connection is connected to the second and/or third fluid connection.

The combustion engine can be the combustion engine of a motor vehicle, in particular. In this context, the cooling channels can pass through the engine block and/or the cylinder head of the combustion engine. The cooling fluid discharge and the cooling fluid entry of the combustion engine are the inlet and outlet respectively of the cooling channels. The cooling fluid can be a water/glycol mixture, which is a known option. The pump pumps the cooling fluid through the cooling system in a manner which is likewise known, i.e. in particular from the inlet line, through the cooling channels of the engine, into the outlet line and, depending on the position of the valve, through the cooler or the bypass. It is of course also possible for more than one cooler to be provided. The flow of cooling fluid passed to the cooler can also pass through an oil/water heat exchanger and/or be fed to a motor vehicle heating system in winter operation.

Via the bypass, cooling fluid coming from the engine can be fed directly, i.e. without passing through elements that cool the fluid, in particular a cooler, back to the inlet from the outlet in a manner known per se. This is desired if the engine has not yet reached operating temperature and the intention is that it should heat up to the operating temperature as quickly as possible. In this state, the cooling fluid is not supposed to be cooled by a cooler or similar.

According to the invention, the valve element for selectively connecting the first connection to the second and/or third connection of the valve assembly is arranged in the outlet and the expansion element is arranged in the inlet. The valve element is connected to the inlet line on the upstream and downstream side. The element is furthermore connected to the bypass. The expansion element, which is arranged in the inlet, is in heat conducting contact with the cooling fluid and is heated in accordance with the temperature of the cooling fluid. During this process, it expands and actuates the valve element accordingly. In this way,

automatic regulation of the flow of cooling fluid coming from the engine through the cooler back into the inlet or, via the bypass, directly into the inlet is accomplished as a function of the temperature of the cooling fluid and hence of the engine temperature. Thus the valve assembly operates as a thermostat and, in particular, it is possible to provide just one valve assembly.

The expansion element actuates the valve element in such a way that, below a limiting temperature, all of the cooling fluid coming from the engine is initially routed back into the inlet via the bypass line. As the expansion element heats up and hence expands, the cooling fluid coming from the engine is initially passed partially through the cooler and partially through the bypass back into the inlet. Above a limiting temperature, all of the cooling fluid coming from the engine is then passed through the cooler under the control of the actuation device or valve element. For the purpose of routing part of the fluid through the cooler and the bypass, the first connection is connected partially to the second connection and partially to the third connection. It is, of course, also possible to provide for the possibility of setting the valve element to a position in which flow from the first connection to the second or third connection is shut off.

According to the invention, the valve element and the actuation device are spatially separated. Since the valve element is arranged on the side on which the cooling fluid is discharged from the engine, the cooler and, in particular, the cooling water hoses are, on the one hand, advantageously not exposed to the full pressure of the fluid in the cold starting phase. Thus damage is reliably prevented, especially in the cold winter months. Since, on the other hand, the expansion element is arranged on the side on which the cooling fluid is admitted to the engine, particularly rapid and hence good regulation is achieved, especially in the cold starting phase of the engine, since the temperature of the cooling fluid is recorded by the expansion element even before it flows through the engine block and/or cylinder head and is accordingly taken into account immediately for regulation. Thus, according to the invention, the respective advantages of

positioning valve assemblies on the admission and the discharge side are combined by providing a discharge thermostat controlled by the admission temperature of the cooling fluid.

According to a refinement, provision can be made for the valve element to comprise a ball valve, which is rotatably supported in a valve housing, wherein the valve housing comprises the at least three fluid connections, wherein the ball valve comprises at least two openings, and wherein the ball valve is rotatable in the valve housing by the expansion element such that the first fluid connection is connected to the second and/or third fluid connection through the openings of the valve element. The valve element can thus be a ball (segment) valve. With such ball valves, particularly precise and, at the same time, robust control is possible. In this arrangement, a hollow sphere (spherical segment) is mounted in such a way that it can be rotated in the housing by means of one or more suitable shafts. A rod or similar connected to the expansion element engages on the valve ball, eccentrically for example, to rotate the latter. However, it is also conceivable that the valve element should comprise a disk valve, which comprises at least one fluid tight disk, the position of which is actuatable by the expansion element such that the first fluid connection is connected to the second and/or third fluid connection. In particular, the disk valve can comprise two disks, each interrupting a link between two connections. For example, one disk can be provided for the link between the first fluid connection and the second fluid connection, and a second disk can be provided for the link between the first fluid connection and the third fluid connection. A flow of cooling fluid coming from the first fluid connection can then be fed completely or partially to the section of the outlet leading to the cooler and/or to the bypass line by appropriate positioning of the disks. It is a simple matter additionally to integrate a pressure relief valve into the cooling system, if required.

According to a particularly practical refinement, the expansion element can be an expanding wax element. Provision can furthermore be made for the expansion

element to actuate the valve element via an actuation rod which is in operative connection with a return spring. The actuation rod then engages on the valve element against the spring force of the return spring and actuates said element when there is a temperature-induced expansion or contraction of the expansion element. If the expansion element does not exert a sufficient force on the return spring, the spring can relax and thereby actuate the valve element in such a way, for example, that cooling fluid coming from the engine is routed directly into the inlet via a bypass. However, it is also possible that, when the spring is free of force, said spring actuates the valve element in such a way that cooling fluid coming from the engine is routed into the inlet through the cooler. As a result, adequate cooling of the engine is ensured at all times if the expansion element fails.

According to a further particularly practical refinement, the pump can be arranged in the inlet downstream of the connection of the bypass line to the inlet. The intake side of the pump is thus downstream of the inflow from the bypass line. In particular, the pump can be arranged substantially directly in front of the cooling fluid entry of the combustion engine, i.e. the entry to the system of cooling channels.

An illustrative embodiment of the invention is explained in greater detail below with reference to the figures. In said figures, which are schematic:

Figure 1 shows a cooling system according to the invention in accordance with a first illustrative embodiment, in a first operating state.

Figure 2 shows the cooling system from figure 1 in a second operating state,

Figure 3 shows a cooling system according to the invention in accordance with a second illustrative embodiment, in a first operating state, and

Figure 4 shows the cooling system from figure 3 in a second operating state.

Unless stated otherwise, identical reference signs refer to identical objects in the figures. Figures 1 and 2 illustrate a cooling system 10 according to the invention for a combustion engine of a motor vehicle. For the sake of clarity, the only part of the combustion engine shown is the engine block 12. Running through the latter is a plurality of cooling channels (not shown in the figures). Furthermore, a cylinder head of the combustion engine (not shown) can likewise have such cooling channels. The cooling system 10 has an inlet line 14, which is connected on the admission side 16 of the engine block 12 to the cooling channels of the latter and, where applicable, of the cylinder head. The cooling system 10 furthermore has an outlet line 18, which, in the example shown, comprises a first section 22, which starts from the discharge side 20 of the engine block 12, said discharge side likewise being connected to the cooling channels, and a second section 24, which adjoins the first section 22. The second section 24 opens as a cooler feed into a cooler 26, in the present case the main cooler, of the cooling system 10. The inlet 14 is connected to the cooler 26 at the outlet of said cooler as a cooler return. In the inlet 14, there is a pump 28 on the admission side 16 of the engine block 12. In particular, the inlet 14 opens into the intake side of the pump 28. The delivery side of the pump 28 is connected to the cooling channels of the engine block 12 and/or of the cylinder head. The pump 28 pumps cooling fluid, in the example illustrated a water/glycol mixture, through the cooling system 10.

The cooling system 10 furthermore has a bypass line 30, which connects the section 22 of the outlet 18 which starts from the cooling water exit of the engine block 12 directly to the inlet 14, bypassing the cooler 26. The intake side of the pump 28 is thus arranged downstream of the connection of the bypass line 30 to the inlet 14. Between the section 22 of the outlet 18 which starts from the discharge side 20 of the engine block 12 and the bypass line 30 and the section 24 of the outlet which leads to the cooler 26 there is a valve element 32. In the illustrative embodiment shown in figures 1 and 2, the valve element 32 is a hollow spherical segment arranged in a valve housing. The valve housing has three fluid connections, a first connection being connected to section 22 of the

inlet, a second connection being connected to section 24 of the inlet 18, and a third connection being connected to the bypass line 30. In the example shown, the hollow spherical segment has two openings. It is rotatably mounted in the housing in a manner known per se. Given appropriate arrangement of the openings of the valve ball, it is possible by rotating the hollow spherical segment to connect the first fluid connection of the housing to the second and/or the third fluid connection.

Figure 1 shows a position of the valve element 32 in which the first connection is connected only to the third connection, while the link to the second connection is shut off. This position is adopted in the cold starting phase of the combustion engine. In this position, cooling fluid pumped out of the inlet 14 through the engine block 12 by the pump 28 thus flows through the first section 22 of the outlet 18 and, from there, flows in full through the bypass line 30, bypassing the cooler 26, back into the inlet 14, as illustrated schematically by the arrows 34 in figure 1. Figure 2 shows a different position of the valve element 32, in which the first connection of the valve housing is connected only to the second connection, while the link to the third connection is shut off. In this position of the valve element 32, all of the cooling fluid pumped out of the inlet 14 through the engine block 12 and into section 22 of the outlet 18 by the pump 28 thus flows through the section 24 of the outlet 18 which opens into the cooler 26, through the cooler 26, and from there back into the inlet 14 and through the engine block 12 etc. This is indicated by the arrows 36 in figure 2. The operating position shown in figure 2 is adopted when the combustion engine has reached its operating temperature. The valve element 32 can also adopt intermediate positions not shown in figures 1 and 2 if the link between the first connection and hence section 22 of the outlet 18, on the one hand, and the second connection and hence section 24 of the outlet 18 and the third connection and hence the bypass line 30, on the other hand, are simultaneously and each partially opened. In this state, therefore, part of the cooling fluid flows through the cooler 26 and part through the bypass line 30, directly back into the inlet 14, depending on the position of the valve element 32.

In the example shown, the valve element 32 is actuated by means of an expansion element 38, in the example shown an expanding wax element 38, arranged in the inlet 14 downstream of the connection of the bypass line 30 to the inlet 14. This is thus in heat conducting contact with the cooling fluid flowing through the inlet 14 and expands or contracts in accordance with the temperature of the cooling fluid. The expansion element 38 is connected to an actuation rod 40, in the present case a working pin 40, which is in turn in operative connection, at its end remote from the expansion element 38, with a return spring 42 arranged in the axial direction of the working pin 40. During movement of the actuation rod 40 owing to an expansion or contraction of the expansion element 38, the valve element 32, in the present case the ball valve, is moved counter to the spring force of the return spring 42 by way of a connecting rod 43 articulated on the actuation rod 40, as is shown in figures 1 and 2. Here, the expansion element 38 is to a large extent contracted in figure 1 and to a large extent expanded in figure 2. It can easily be seen that any desired mixing ratios of the cooling fluid routed through the cooler 26, on the one hand, and the bypass line 30, on the other hand, can be set in an infinitely variable manner, in addition to the two positions of the valve element 32 which are shown in figures 1 and 2.

Figures 3 and 4 show a cooling system 10 according to the invention in accordance with a second illustrative embodiment. Figure 3 once again shows the operating position in the cold starting phase of the combustion engine, while figure 4 shows the operating position when the operating temperature of the combustion engine is reached. The cooling system 10 shown in figures 3 and 4 largely corresponds to the cooling system shown in figures 1 and 2. However, it differs in the valve element from the cooling system 10 shown in figures 1 and 2. In figures 3 and 4, a disk valve element 44 is provided. In the example shown, the valve element 44 has two valve disks 46, 48, which are arranged coaxially to one another on the actuation rod 40 actuated by the expansion element 38. Upon actuation of the actuation rod 40 by the expansion element 38, the valve disks 46,

48 are thus moved in the axial direction of the actuation rod 40 counter to the return force of a return spring 50.

In the operating position shown in figure 3, the expansion element 38 is expanded to the minimum extent. In this position, the link between the first fluid connection and the second fluid connection is completely shut off, with the result that all the cooling fluid pumped through the engine block 12 flows directly back into the inlet 14 from the discharge side 20 of the engine block 12 through the bypass line 30, as indicated by the arrows 34 in figure 3. In particular, the second valve disk 48 shuts off the link to the section 24 of the outlet 18 which opens into the cooler 26. In the operating position shown in figure 4, the expansion element 38 is, by contrast, expanded, with the result that the first valve disk 46 of the valve element 44 shuts off the link between the section 22 of the outlet 18 coming from the cooling water discharge 20 of the engine block 12 and the bypass line 30, with the result that all the cooling fluid pumped through the engine block 12 flows back into the inlet 14 via section 24 of the outlet 18 and the cooler 26, as indicated by the arrows 36 in figure 4.

In both illustrative embodiments, the return spring 42, 50 actuates the respective valve element 32, 44 in such a way when free of force, i.e. when the expansion element 38 is not expanded, as illustrated in both figures 1 and 3, that all the cooling fluid coming from the engine block 12 is passed back directly into the inlet 14 through the bypass line 30. When the expansion element 38 is expanded, as shown in figures 2 and 4, on the other hand, the return spring 42, 50 is in each case compressed.

By means of the admission-side control, in accordance with the invention, of the valve element arranged on the discharge side by means of an expansion element, particularly rapid temperature regulation with simultaneous reliable avoidance of damage, especially to the cooling hoses, at low temperatures is achieved.

CLAIMS:

1. A cooling system for a combustion engine, comprising
 - an inlet (14) for cooling fluid, which is connectable to cooling channels of the combustion engine (12), and an outlet (18) for cooling fluid, which is also connectable to the cooling channels of the combustion engine (12),
 - a pump (28) for pumping the cooling fluid through the inlet (14) and outlet (18),
 - a cooler (26) for cooling the cooling fluid, which is connected to the outlet (18) on the one hand and the inlet (14) on the other hand, and a bypass line (30), which connects the outlet (18) to the inlet (14) without passing through the cooler (26), and
 - a valve assembly (32) comprising a valve element (32, 44) and an actuation device (38) for actuating the valve element (32, 44),
 - characterized in that
 - the valve element (32, 44) is arranged in the outlet (18) and comprises at least three fluid connections, wherein a first fluid connection is connected to a section (22) of the outlet (18) coming from a cooling fluid discharge (20) of the combustion engine (12), a second fluid connection is connected to a section (24) of the outlet (18) leading to the cooler (26) and a third fluid connection is connected to the bypass line (30) leading to the inlet (14), and
 - the actuation device (38) comprises an expansion element (38), which is arranged in the inlet (14) downstream of the connection of the bypass line (30) to the inlet (14), and with which expansion element the valve element (32, 44) is actuatable such that the first fluid connection is connected to the second and/or third fluid connection.

2. The cooling system as claimed in claim 1, characterized in that the valve element (32) comprises a ball valve (32), which is rotatably supported in a valve housing, wherein the valve housing comprises the at least three fluid connections, wherein the ball valve (32) comprises at least two openings, and wherein the ball valve (32) is rotatable in the valve housing by the expansion element (28) such that the first fluid connection is connected to the second and/or third fluid connection through the openings of the valve element (32).
3. The cooling system as claimed in claim 1, characterized in that the valve element (44) comprises a disk valve (44), which comprises at least one fluid tight disk (46, 48), whose position is actuatable by the expansion element (38) such that the first fluid connection is connected to the second and/or third fluid connection.
4. The cooling system as claimed in one of the preceding claims, characterized in that the expansion element (38) is an expanding wax element.
5. The cooling system according to one of the preceding claims, characterized in that the expansion element (38) actuates the valve element (32, 44) via an actuation rod (40) which is in operative connection with a return spring (42, 50).
6. The cooling system as claimed in one of the preceding claims, characterized in that the pump (28) is arranged in the inlet (14) downstream of the connection of the bypass line (30) to the inlet (14).

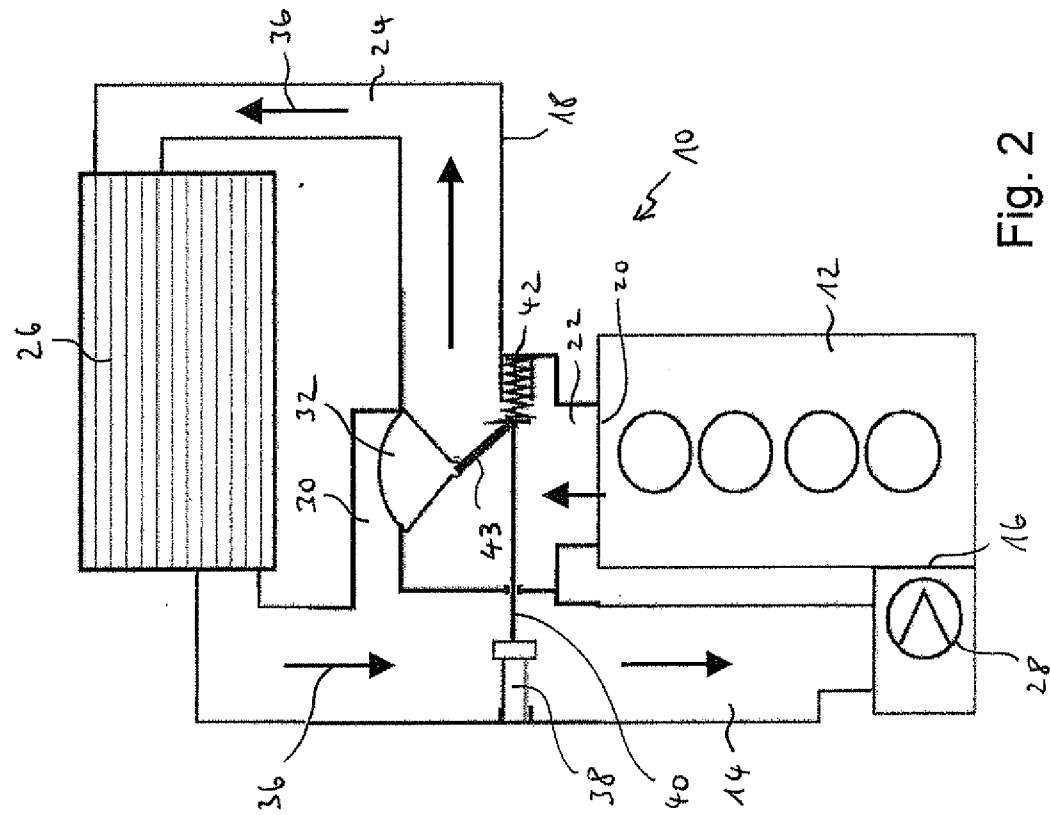


Fig. 2

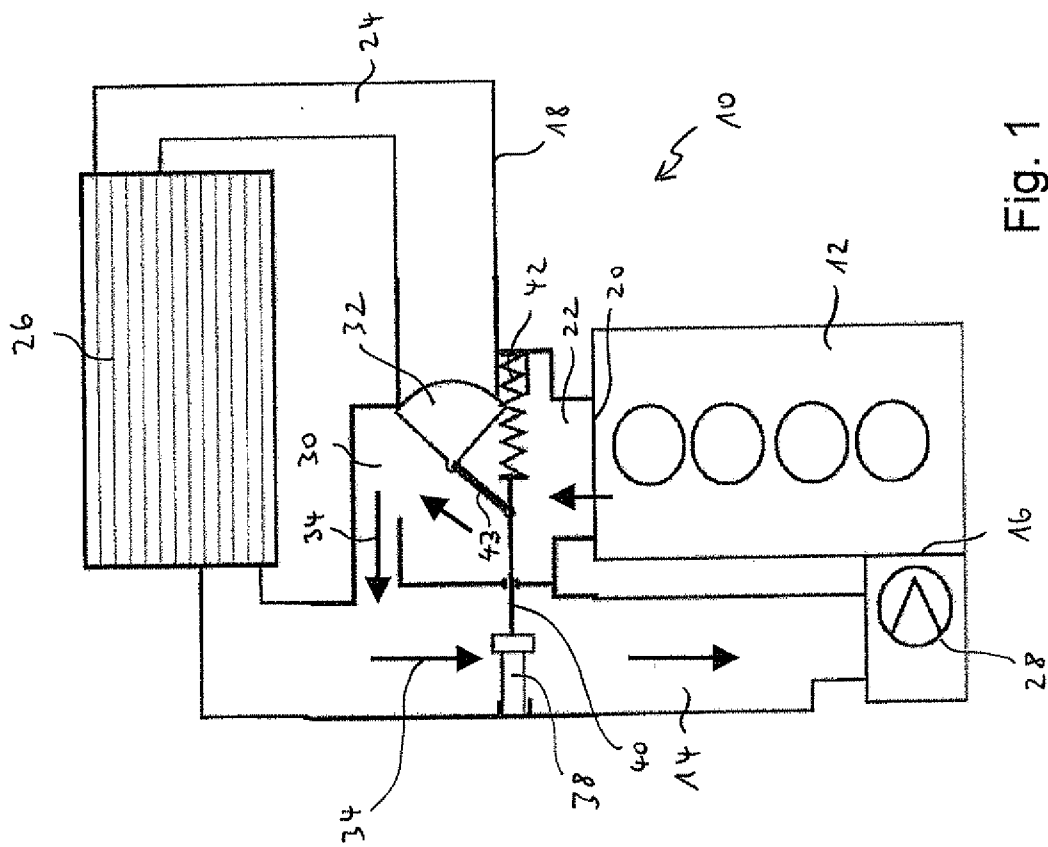
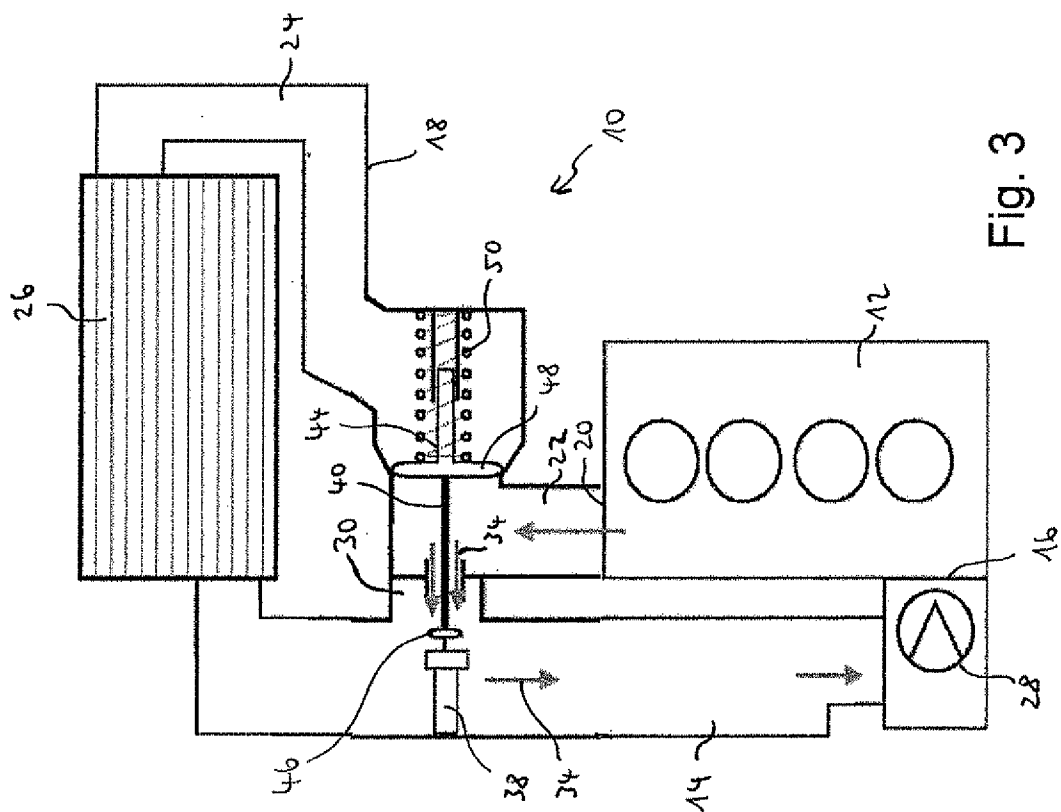
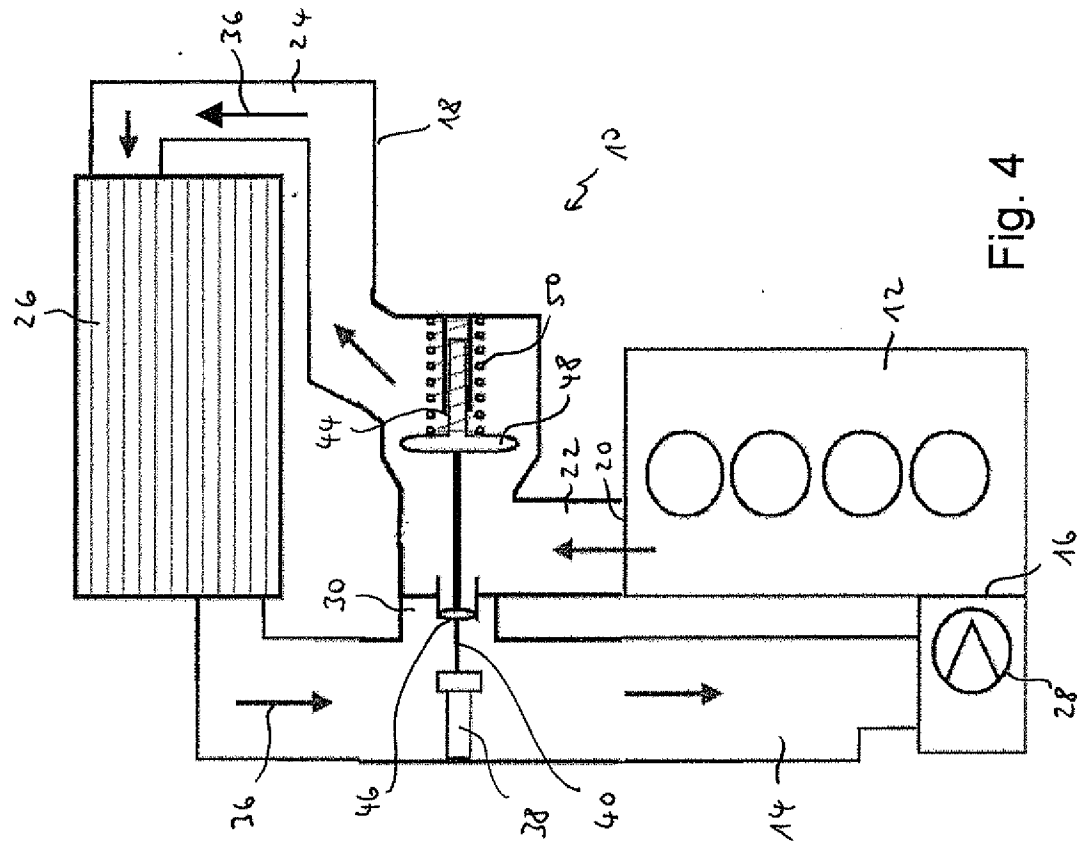


Fig. 1



INTERNATIONAL SEARCH REPORT

International application No
PCT/US2010/039583

A. CLASSIFICATION OF SUBJECT MATTER

INV. F01P7/16
ADD.

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)
F01P

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)

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 008 241 A (KLOECKNER HUMBOLDT DEUTZ AG) 31 May 1979 (1979-05-31)	1,2,6
Y	page 2, lines 34-44; figures 1,2 page 2, lines 45-103	3-5
Y	----- EP 1 111 215 A1 (FORD GLOBAL TECH INC [US]) 27 June 2001 (2001-06-27) paragraphs [0029], [0030], [0031], [0034] - [0038]; figures 3,4	3-5
A	----- DE 23 47 038 A1 (ROBIONEK HANS JOACHIM) 27 March 1975 (1975-03-27) page 7, paragraphs 1,2 - page 8, paragraph 1; figures 1,2	1-6
A	----- EP 0 870 911 A2 (BAYERISCHE MOTOREN WERKE AG [DE]) 14 October 1998 (1998-10-14) column 5, lines 26-41	1-6

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

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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Date of the actual completion of the international search

8 November 2010

Date of mailing of the international search report

17/11/2010

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
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