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(54) **Cooling structure for internal combustion engine**

Kühlstruktur für Brennkraftmaschine

Structure de refroidissement pour un moteur à combustion interne

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Description

[0001] The present invention relates to a cooling structure for cooling an internal combustion engine with use of coolant.

[0002] There already has been proposed a cooling structure in which a cylinder and a cylinder head are respectively piped and controlled for cooling independently of each other so as to cool an internal combustion engine minutely in accordance with an operational condition of the engine.

[0003] For example, in a cooling structure disclosed in Japanese Patent Laid Open No. 73770/2000, as in Fig. 19 which illustrates a coolant flow, a feed passage 04 branches in a change-over valve 06 and is connected both a cylinder 02 and a cylinder head 03 in an internal combustion engine 01, and coolant can be fed to the cylinder 02 and the cylinder head 03 selectively by operation of the change-over valve 06.

[0004] The change-over valve 06 is actuated through a drive unit 013 in accordance with a control signal provided from a control unit 012.

[0005] As in an ordinary type of an internal combustion engine, coolant can flow from the cylinder 02 to the cylinder head 03, and a return passage 05 extends from the cylinder head 03.

[0006] In the feed passage 04, which is connected to a water pump 07, there are installed not only the change-over valve 06 but also a thermostat 08. Coolant can be allowed to flow selectively along a passage which makes a detour from the return passage 05 to the feed passage 04 through a radiator 09 and along a bypass passage 010 which communicates with the feed passage 04 directly from the return passage 05.

[0007] When the engine load is low, as in Fig. 19 showing a coolant flow with solid-line arrows, the change-over valve 06 is controlled to cut off the coolant flow to the cylinder 02, allowing coolant to circulate to only the cylinder head 03. When the temperature is low, the thermostat 08 closes the passage passing through the radiator 09 and opens the bypass passage 010 and the water pump 07 operates, causing the coolant not passing through the radiator 09 to flow to only the cylinder head 03, thereby suppressing a drop in temperature of the gas remaining in a combustion chamber.

[0008] When the engine load is high, the change-over valve 06 is operated so as to permit the coolant to flow to the cylinder 02 and the operation of the thermostat 08 switches over so that coolant circulates through the radiator 09, whereby the coolant cooled in the radiator 09 circulates through the cylinder 02 and the cylinder head 03 to cool the whole of the engine.

[0009] Thus, since the control for cooling the cylinder 02 and the cylinder head 03 is performed by actuating the change-over valve 06 according to engine load conditions, both control unit 012 and drive unit 013 are needed for actuating the change-over valve 06, resulting in that the structure becomes complicated and the cost high.

[0010] Moreover, when the engine load is low, coolant circulates through only the cylinder head 03 and does not flow through the cylinder 02, so it follows that coolant stays in a water jacket of the cylinder 02. That the coolant flows through only the cylinder head 03 may rather deteriorate the effect of suppressing a drop in temperature of the gas remaining in the cylinder portion. Consequently, when the engine load is high and sufficient cooling is needed, there is a fear that cooling of the cylinder head portion may be delayed by the coolant remaining in the heated cylinder portion, with consequent likelihood of knocking.

[0011] An skin cooling structure is also disclosed by JP63016122.

[0012] The present invention has been accomplished in view of the above-mentioned points and it is an object of the invention to provide a cooling structure for an internal combustion engine less expensively wherein, according to the temperature of coolant, the flow of coolant to a cylinder and a cylinder head is controlled without allowing the coolant to stay in the cylinder and wherein with such a simple structure it is possible to expect both the effect of suppressing a drop in temperature of residual gas and an anti-knocking effect.

[0013] For achieving the above-mentioned object, according to the invention defined in claim 1 there is provided a cooling structure for an internal combustion engine, comprising a first coolant circulation system provided with a first thermostat for adjusting the amount of coolant to be circulated between a radiator and the internal combustion engine and a second coolant circulation system provided with a second thermostat, the second thermostat making control so that the coolant circulates in parallel to a cylinder and a cylinder head when the temperature of the coolant is lower than a predetermined coolant temperature, while when the coolant temperature is higher than the predetermined coolant temperature, the coolant circulates in series from the cylinder to the cylinder head.

[0014] Thus, with the second thermostat in the second coolant circulation system, the coolant circulates in parallel to the cylinder and the cylinder head when the coolant temperature is low, while when the coolant temperature is high, the coolant circulates in series from the cylinder to the cylinder head, so it is not necessary to make control using a control unit nor is it necessary to use a drive unit; in other words, it is possible to attain a structural simplification and the reduction of cost.

[0015] When the coolant temperature is low, the coolant is allowed to circulate directly through the cylinder head and is also allowed to flow through the cylinder, the coolant does not stay in the cylinder and it is possible to expect the effect of suppressing a drop in temperature of the gas remaining in the combustion chamber in comparison with allowing the coolant to stay in the cylinder.

[0016] Further, since the coolant does not stay in the cylinder, when cooling is required, it is possible to avoid

the occurrence of knocking which would occur due to delayed cooling in the presence of residual coolant heated in the cylinder.

[0017] According to the invention defined in claim 2 there is provided, in combination with the invention defined in claim 1, a cooling structure for an internal combustion engine, wherein when the coolant circulates in parallel to the cylinder and the cylinder head while being controlled by the second thermostat in the second coolant circulation system, most of the coolant flows directly to the cylinder head and the remaining portion of the coolant flows to the cylinder.

[0018] When the coolant circulates in parallel to the cylinder and the cylinder head at a low temperature of the coolant, a control is made so that the coolant directly flows mainly to the cylinder head and slightly flows to the cylinder, whereby a drop in temperature of residual gas can be suppressed more effectively.

[0019] According to the invention defined in claim 3 there is provided, in combination with the invention defined in claim 1 or claim 2, a cooling structure for an internal combustion engine wherein a valve operating temperature in the second thermostat is set higher than that in the first thermostat.

[0020] When the coolant temperature is low, coolant which does not go through the radiator circulates in parallel to the cylinder head and the cylinder to suppress a drop in temperature of residual gas. As the temperature rises, the first thermostat is the first to operate and coolant flows through the radiator and circulates in parallel with the cylinder head and the cylinder to cool particularly the cylinder head. As the temperature further rises to a high temperature, the second thermostat operates, allowing the coolant to circulate in series from the cylinder to the cylinder head and thereby cooling the whole of the internal combustion engine.

[0021] According to the invention defined in claim 4 there is provided, in combination with the invention defined in any of claims 1 to 3, a cooling structure for an internal combustion engine wherein in each of the first and second thermostats a valve element is actuated in accordance with expansion and contraction of wax contained in a temperature sensor portion which is for detecting the temperature of the circulating coolant.

[0022] It is possible to utilize the conventional thermostat of the structure wherein wax contained in the interior of a temperature sensing portion expands and contracts according to coolant temperatures and such changes between expansion and contraction cause a valve element to open and close. Therefore, it is possible to attain the reduction of cost.

[0023] According to the invention defined in claim 5 there is provided, in combination with the invention defined in any of claims 1 to 4, a cooling structure for an internal combustion engine wherein the first thermostat is disposed between a coolant outlet of the radiator and the internal combustion engine.

[0024] By closing the coolant outlet side of the radiator with use of the first thermostat there is constituted a circulation path within the internal combustion engine alone without going through the radiator, while by opening the coolant outlet side of the radiator the coolant after passing through the radiator circulates in the internal combustion engine.

[0025] According to the invention defined in claim 6 there is provided, in combination with the invention defined in any of claims 1 to 4, a cooling structure for an internal combustion engine wherein the first thermostat is disposed between a coolant inlet of the radiator and the internal combustion engine.

[0026] By closing the coolant inlet side of the radiator with use of the first thermostat there is constituted a circulation path within the internal combustion engine alone without going through the radiator, while by opening the coolant inlet side of the radiator the coolant after passing through the radiator circulates in the internal combustion engine.

[0027] According to the invention defined in claim 7 there is provided a cooling structure for an internal combustion engine, comprising a first coolant circulation system provided with a first thermostat for adjusting the amount of coolant to be circulated between a radiator and the internal combustion engine, and a second coolant circulation system provided with a second thermostat, the second thermostat making control so that the coolant circulates in parallel to a cylinder and a cylinder head when the temperature of the coolant is lower than a predetermined coolant temperature, while when the coolant temperature is higher than the predetermined coolant temperature, the coolant circulates in series from the cylinder head to the cylinder.

[0028] With the second thermostat in the second coolant circulation system, the coolant circulates in parallel to the cylinder and the cylinder head at a low temperature, while at a high temperature the coolant circulates in series from the cylinder head to the cylinder, so that it is not necessary to make control using a control unit nor is it necessary to use a drive unit, thus making it possible to attain the simplification of structure and reduction of cost.

[0029] Besides, since the coolant always flows into the cylinder head first, the temperature of the coolant which cools the cylinder head does not change even if switching is made from one to another flow path, and thus it is possible to cool the cylinder head more strongly than in the prior art.

[0030] Since at a low temperature the coolant is allowed to flow directly to the cylinder head and is also allowed to flow to the cylinder, the coolant does not stay in the cylinder and it is possible to expect a temperature drop suppressing effect of the residual gas in the combustion chamber as compared with the case where the coolant is allowed to stay in the cylinder.

[0031] Moreover, since the coolant does not stay in the cylinder, when cooling is needed, it is possible to avoid the occurrence of knocking caused by delayed

cooling due to heated coolant staying in the cylinder.

[0032] When the temperature is high, the coolant flows in series from the cylinder head to the cylinder, so that powerful cooling is ensured and it is possible to prevent worsening of the knocking level.

[0033] According to the invention defined in claim 8 there is provided, in combination with the invention defined in claim 7, a cooling structure for an internal combustion engine wherein a valve operating temperature in the second thermostat is set higher than that in the first thermostat.

[0034] When the temperature is low, the coolant which does not go through the radiator circulates in parallel to the cylinder head and the cylinder to suppress the drop in temperature of residual gas, while as the temperature rises, the first thermostat operates first and the coolant flows through the radiator and circulates in parallel to the cylinder head and the cylinder, cooling particularly the cylinder head. Then, when the temperature further rises to a high temperature, the second thermostat operates, allowing the coolant to circulate in series from the cylinder head to the cylinder, thereby cooling the whole of the internal combustion engine.

[0035] According to the invention defined in claim 9 there is provided, in combination with the invention defined in claim 7 or claim 8, a cooling structure for an internal combustion engine wherein the first thermostat is disposed between a coolant outlet of the radiator and the internal combustion engine.

[0036] By closing the coolant outlet side of the radiator with use of the first thermostat there is constituted a circulation path in the internal combustion engine alone without going through the radiator, while by opening the coolant outlet side of the radiator the coolant which has passed through the radiator circulates in the internal combustion engine.

[0037] According to the invention defined in claim 10 there is provided, in combination with the invention defined in claim 9, a cooling structure for an internal combustion engine, further including a branching means for branching the flow of coolant so that most of the coolant is fed to the cylinder head and the remaining coolant is fed to the cylinder, and wherein the second thermostat is disposed between a coolant inlet of the radiator and the internal combustion engine, and when the coolant temperature is lower than the predetermined temperature, the second thermostat opens a valve disposed on the cylinder head side to let the coolant circulate in parallel to the cylinder and the cylinder head, while when the coolant temperature is higher than the predetermined temperature, the second thermostat closes the cylinder head-side valve and opens a cylinder-side valve to let the coolant circulate in series from the cylinder head to the cylinder.

[0038] When the temperature is not lower than the temperature at which the first thermostat opens the coolant outlet side of the radiator and is lower than the predetermined temperature, the second thermostat opens the cylinder head-side valve, thereby allowing the coolant to circulate in parallel to the cylinder and the cylinder head and circulate directly to the cylinder head, with the coolant flowing also to the cylinder. Therefore, the coolant does not stay in the cylinder and it is possible to expect a temperature drop suppressing effect of residual gas in the combustion chamber as compared with the case where the coolant is allowed to stay in the cylinder.

[0039] When the temperature is higher than the predetermined temperature, the coolant flows in series from the cylinder head to the cylinder, so powerful cooling is ensured and it is possible to prevent worsening of the knocking level.

[0040] Preferred embodiments of the present invention will be described hereinunder with reference to the accompanying drawings, in which:

Fig. 1 is a sectional view showing a state in which the temperature of cooling water is low in a cooling structure for an internal combustion engine according to an embodiment of the present invention;

Fig. 2 is a sectional view taken along line II-II in Fig. 1;

Fig. 3 is a block diagram showing a flow of cooling water;

Fig. 4 is a sectional view showing a state in which the temperature of cooling water is medium in the internal combustion engine cooling structure;

Fig. 5 is a sectional view taken along line V-V in Fig. 4;

Fig. 6 is a block diagram showing a flow of cooling water;

Fig. 7 is a sectional view showing a state in which the temperature of cooling water in the internal combustion engine cooling structure is high;

Fig. 8 is a sectional view taken along line VIII-VIII in Fig. 1;

Fig. 9 is a block diagram showing a flow of cooling water;

Fig. 10 is a block diagram showing a flow of cooling water at a low cooling water temperature in a cooling structure for an internal combustion engine according to another embodiment of the present invention;

Fig. 11 is a block diagram showing a flow of cooling water at a medium cooling water temperature in the cooling structure;

Fig. 12 is a block diagram showing a flow of cooling water at a high cooling water temperature in the cooling structure;

Fig. 13 is a block diagram showing a flow of cooling water at a low cooling water temperature in a cooling structure for an internal combustion engine according to a further embodiment of the present invention;

Fig. 14 is a block diagram showing a flow of cooling water at a medium cooling water temperature in the cooling structure;

Fig. 15 is a block diagram showing a flow of cooling water at a high cooling water temperature in the cooling structure;

Fig. 16 is a block diagram showing a flow of cooling water at a low cooling water temperature in a cooling structure for an internal combustion engine according to a still further embodiment of the present invention;

Fig. 17 is a block diagram showing a flow of cooling water at a medium cooling water temperature in the cooling structure;

Fig. 18 is a block diagram showing a flow of cooling water at a high cooling water temperature in the cooling structure; and

Fig. 19 is a block diagram showing a conventional cooling water flow.

[0041] An embodiment of the present invention will be described hereinunder with reference to Figs. 1 to 9.

[0042] In a cooling structure for an internal combustion engine 1 according to this embodiment, the state at a low temperature is shown in Figs. 1 to 3, the state at a medium temperature is shown in Figs. 4 to 6, and the state at a high temperature is shown in Figs. 7 to 9.

[0043] The cooling structure will be described below with reference to Figs. 1 and 2.

[0044] Although a cylinder block 2 and a cylinder head 3 in the internal combustion engine 1 are illustrated separately from each other, both are actually joined together through a gasket. A water jacket 2a formed around a cylinder bore in the cylinder block 2 is in communication through a gasket hole with a water jacket formed around a combustion chamber in the cylinder head 3.

[0045] In the cylinder head 3, as shown in Fig. 2, a water pump 4 and a first thermostat 5 are adjacent each other.

[0046] In the first thermostat 5, a cylindrical valve element 5a serving also as a temperature sensing portion with wax contained therein slides axially in response to a change in temperature, thereby controlling communication and cut-off between an inlet port 5b and an outlet port 5d, the inlet port 5b being in communication with a cooling water outlet 10b of a radiator 10 through a pipe 11, and also controlling communication and cut-off between an inlet port 5c and the outlet port 5d, the inlet port 5c being in communication through a bypass 7 and a connecting pipe 6 with a cooling water outlet 3a formed in the water jacket of the cylinder head 3.

[0047] In the first thermostat 5, the temperature sensing portion senses the temperature of cooling water, and if the temperature is not higher than 80°C, the valve element 5a closes the input port 5b communicating with the radiator 10 and causes the other input port 5c communicating with the bypass 7 to open into communication with the outlet port 5d, as shown in Fig. 2.

[0048] When the temperature exceeds 80°C, the valve element 5a closes the inlet port 5c communicating with the bypass 7 and causes the other inlet port 5b communicating with the radiator 10 to open into communication with the outlet port 5d, as shown in Fig. 5 (Fig. 8).

[0049] The first thermostat 5 is of a conventional structure wherein wax contained in a temperature sensing portion expands and contracts according to temperatures of circulating cooling water and such changes between expansion and contraction cause a valve element to open and close. Thus, it is possible to utilize the conventional thermostat and thereby attain the reduction of cost.

[0050] The cooling water outlet 3a formed in the water jacket of the cylinder head 3 branches into passages, one of which is connected to the bypass 7 and the other connected to a cooling water inlet 10a of the radiator 10 through a pipe 12 (see Fig. 1).

[0051] As shown in Fig. 2, the outlet port 5d of the first thermostat 5 is in communication with a cooling water suction port 4a of the water pump 4.

[0052] A discharge port 4b of the water pump 4 is in communication with an inlet port 20a of a second thermostat 20 through a pipe 13 (see Fig. 1).

[0053] In the second thermostat 20, a cylindrical member 21 provided centrally with a wax-containing temperature sensing portion 21a of a larger diameter is supported slidably by holders 24 and 25, and a first valve element 22 and a second valve element 23, which are disc-like, are integrally fitted on the cylindrical member 21 on both sides of the temperature sensor portion 21a. Thus, the conventional thermostat is utilized.

[0054] A hollow disc-like valve seat of the holder 24 with which the first valve element 22 is in contact partitions the interior of a case of the second thermostat 20 into a body side and an outlet port 20b side. On the other hand, the second valve element 23 opens and closes another outlet port 20c.

[0055] The outlet port 20b is in communication with the water jacket 2a of the cylinder block 2 through a pipe 14, while the other outlet port 20c is in direct communication with the water jacket of the cylinder head 3 through a pipe 15.

[0056] In the second thermostat 20, the temperature sensing portion 21a senses the temperature of cooling water, and if the temperature is not higher than 100°C, the first valve element 22 closes the outlet port 20b and at the same time the second valve element 23 opens the outlet port 20c into communication with the inlet port 20a, as shown in Fig. 1.

[0057] If the temperature exceeds 100°C, as shown in Fig. 7, the second valve element 23 closes the outlet port 20c and the first valve element 22 opens the outlet port 20b into communication with the inlet port 20a.

[0058] In the second thermostat 20, a through hole 27 serving also as an air vent is formed along a peripheral edge portion of the valve seat of the holder 24 which partitions the interior of the case of the second thermostat 20 into the body side and the outlet port 20b side, to constantly provide communication between the inlet port 20a side and the outlet port 20b side in the interior

of the case.

[0059] The internal combustion engine 1 has the above cooling structure. Now, with reference to Figs. 1 to 9, the following description is provided about how the flowing path of cooling water changes according to cooling water temperatures.

[0060] First, in a low-temperature operation condition with the cooling water temperature not higher than 80°C, as shown in Figs. 1 to 3, the valve element 5a in the first thermostat 5 closes the inlet port 5b communicating with the radiator 10 and causes the other inlet port 5c communicating with the bypass 7 to open into communication with the outlet port 5d, allowing cooling water recycled from the cylinder head 3 to pass through the bypass 7 and enters the inlet port 5c in the first thermostat 5 without circulating through the radiator 10, further allowing it to be sucked into the water pump 4 from the outlet port 5d and be discharged to the second thermostat 20 from the discharge port 4b of the pump through the pipe 13.

[0061] In the second thermostat 20, the first valve element 22 closes the outlet port 20b and at the same time the second valve element 23 opens the outlet port 20c into communication with the inlet port 20a. Consequently, the cooling water discharged from the water pump 4 enters the inlet port 20a of the second thermostat 20 and flows out from the outlet port 20c directly into the water jacket of the cylinder head 3 through the pipe 15.

[0062] On the other hand, a portion of the cooling water which has entered the inlet port 20a in the second thermostat 20 passes through the through hole 27 formed in the holder flows out from the outlet port 20b into the water jacket 2a of the cylinder block 2, and circulates to the water jacket of the cylinder head 3.

[0063] The flow of cooling water in the state of operation at a cooling water temperature of not higher than 80°C described above can be schematically illustrated as in Fig. 3.

[0064] As shown in the same figure, cooling water discharged from the water pump 4 flows from the second thermostat 20 in parallel to the cylinder head 3 and the cylinder block 2. In this case, most of the cooling water flows directly to the cylinder head 3 (thick solid-line arrows in Figs. 1 and 3) and the remaining portion of the cooling water flows to the cylinder block 2 and thence to the cylinder head 3 (thin solid-line arrows in Figs. 1 and 3).

[0065] The cooling water thus joined in the cylinder head 3 flows to the first thermostat 5 through the bypass 7 without flowing through the radiator 10 and is thence recycled to the water pump 4, whereby a drop in temperature of the gas remaining in the combustion chamber can be suppressed.

[0066] Since cooling water is allowed to circulate directly through the cylinder head 3 when the temperature thereof is low and is also allowed to flow through the cylinder block 2 though the amount thereof is small, the cooling water does not stay in the cylinder block 2 and hence a drop in temperature of the gas remaining in the combustion chamber can be suppressed more effectively.

[0067] Next, when the cooling water temperature exceeds 80°C and not higher than 100°C, as shown in Figs. 4 to 6, the valve element 5a in the first thermostat 5 operates and closes the inlet port 5c communicating with the bypass 7 and opens the inlet port 5b communicating with the radiator 10, so that the cooling water recycled from the cylinder head 3 flows to the radiator 10 (see Fig. 5).

[0068] On the other hand, the second thermostat 20 operates in the same manner as is the case with the cooling water temperature being 80°C; that is, the first valve element 22 closes the output port 20b and the second valve element 23 opens the output port 20c into communication with the inlet port 20a, allowing most of the cooling water to flow directly to the cylinder head 3 (thick solid-line arrows in Figs. 4 and 6) and the remaining cooling water to flow to the cylinder block 2 (thin solid-line arrows in Figs. 4 and 6).

[0069] Thus, most of the cooling water which has circulated through the radiator 10 and hence lost its heat and become low in temperature flows directly to the cylinder head 3 and cools the combustion chamber positively.

[0070] A portion of cooling water flowing out from the through hole 27 also flows through the cylinder block 2 to the cylinder head 3 and thus there is no stay of cooling water in the cylinder block 2.

[0071] Therefore, unlike the conventional engine cooling structure wherein when the cylinder head 3 is to be cooled, a high-temperature cooling water staying in the cylinder block 2 flows to the cylinder head 3 and impedes cooling of the cylinder head 3, with consequent occurrence of knocking for example, it is possible to avoid such an inconvenience.

[0072] When the cooling water temperature further rises and exceeds 100°C, as shown in Figs. 7 to 9, the first thermostat 5 operates in the same manner as in the previous case, that is, the valve element 5a closes the inlet port 5c and opens the inlet port 5b communicating with the radiator 10 (see Fig. 8), so that the cooling water recycled from the cylinder head 3 flows to the radiator 10.

[0073] On the other hand, the second thermostat 20 operates and the first valve element 22 opens the outlet port 20b, while the second valve element 23 closes the outlet port 20c, as shown in Fig. 7.

[0074] Thus, as shown in Fig. 9, there is formed a circulation path such that cooling water discharged from the water pump 4 flows through the second thermostat 20, cylinder block 2, cylinder head 3, radiator 10 and first thermostat 5 in this order, then returns to the water pump 4.

[0075] Cooling water which has flowed through the radiator 10 further flows from the second thermostat 20 in

series to the cylinder block 2 and the cylinder head 3, with a large amount of cooling water flowing also to the cylinder block 2, whereby the whole of the internal combustion engine 1 can be cooled positively.

[0076] Thus, the flow of cooling water is controlled by two thermostats 5 and 20. Particularly, the second thermostat 20 is used for controlling the flow of cooling water to the cylinder block 2 and the cylinder head 3. In other words, it is not necessary to use a control unit for control and a drive unit, whereby the structure is simplified and it is possible to attain the reduction of cost.

[0077] Although in the construction of the above embodiment the first thermostat 5 is provided through the pipe 11 in the cooling water outlet 10b of the radiator 10 and is connected to the internal combustion engine 1, it may be provided in the cooling water inlet side of the radiator. In this connection, a cooling structure according to another embodiment of the present invention will be described below with reference to Figs. 10 to 12 which are block diagrams in different temperature conditions.

[0078] In this embodiment, other main components than a first thermostat 30 are the same as in the previous embodiment and so will be described below using the same reference numerals as above.

[0079] In the first thermostat 30, an outlet port is connected to a cooling water inlet of a radiator 10, another outlet port is connected to a suction port of a water pump 4, and an inlet port is connected to a cooling water outlet of a water jacket formed in a cylinder head 3.

[0080] In a low temperature running condition with the cooling water temperature not higher than 80°C, as shown in Fig. 10, the outlet port communicating with the radiator 10 is closed, while the outlet port connected to the suction port of the water pump 4 is opened.

[0081] Cooling water recycling from the cylinder head 3 enters the inlet port of the first thermostat 30, then flows out from the outlet port communicating with the pump suction port and is sucked into the water pump 4 without circulating through the radiator 10, then is discharged from a pump discharge port 4b to a second thermostat 20.

[0082] In the second thermostat 20, a first valve element 22 closes an outlet port 20b and at the same time a second valve element 23 opens an outlet port 20c, communicating with an inlet port 20a. Therefore, the cooling water discharged from the water pump 4 enters the inlet port 20a in the second thermostat 20, flows out from the outlet port 20c and directly into the water jacket formed in the cylinder head 3 through a pipe 15 (thick solid-line arrows in Fig. 10). At the same time, a portion of the cooling water which has entered the inlet port 20a passes through a through hole 27 formed in a holder 24, flows out from the outlet port 20b and enters a water jacket 2a in a cylinder block 2 through a pipe 14 (thin solid-line arrows in Fig. 10), then circulates into the water jacket in the cylinder head 3.

[0083] The cooling water having thus gathered in the cylinder head 3 flows through the first thermostat 5 and circulates to the water pump 4 without going through the radiator 10, thus making it possible to suppress the drop in temperature of the gas remaining in the combustion chamber.

[0084] When the temperature is low, since cooling water is allowed to circulate directly through the cylinder head 3 and is also allowed to flow in the cylinder block 2 though the amount thereof is small, cooing water does not stay in the cylinder block 2 and hence it is possible to suppress the drop in temperature of the residual gas in the combustion chamber more effectively.

[0085] Next, when the cooling water temperature exceeds 80°C and is not higher than 100°C, as shown in Fig. 11, a first thermostat 5 closes an inlet port communicating with the water pump 4 and opens an outlet port 5b communicating with the radiator 10, allowing cooling water recycling from the cylinder head 3 to flow to the radiator 10.

[0086] Consequently, most of the cooling water whose heat has been taken off during circulation in the radiator 10 and which has therefore become low in temperature flows directly to the cylinder head 3 (thick solid-line arrows in Fig. 11), cooling the combustion chamber positively.

[0087] A portion of the cooling water also flows to the cylinder block 2 through the through hole 27 and thence to the cylinder head 3 (thin solid-line arrows in Fig. 11). Thus, the cooling water does not stay in the cylinder block 2.

[0088] When the cooling water temperature further rises and exceeds 100°C, as shown in Fig. 12, the first valve element 22 in the second thermostat 20 opens the outlet port 20b and the second valve element 23 closes the output port 20c, allowing the cooling water which has passed through the radiator 10 to flow from the second thermostat 20 to the cylinder block 2 and the cylinder head 3 in series, as shown in Fig. 12, with a large amount of cooling water being allowed to flow also through the cylinder block 2, whereby the whole of the internal combustion engine 1 can be cooled positively.

[0089] The following description is now provided about a cooling structure for an internal combustion engine according to a further embodiment of the present invention.

[0090] Figs. 13 to 15 are block diagrams of the cooling structure in three different temperature conditions.

[0091] This embodiment is different from the foregoing embodiment illustrated in Figs. 1 to 9 in the structure and arrangement of a second thermostat used therein and also in that a joint 41 is provided in the place of the second thermostat 20 used in that previous embodiment. Since other principal components used in this embodiment are the same as in that previous embodiment, they are identified by the same reference numerals.

[0092] A first thermostat 5 is disposed in a cooling water outlet of a radiator 10 and to which of cylinder 3 side and radiator 10 side cooling water is to flow can be

switched with 80°C as a boundary.

[0093] A joint 41 permits most of cooling water discharged from a water pump 4 to be fed to the cylinder head 3 and a portion thereof to be fed to a cylinder block 2 through an orifice.

[0094] In a second thermostat 40, an output port communicates with a cooling water inlet of the radiator 10 and one of two inlet ports communicates with a water jacket formed in the cylinder head 3, while the other is in communication with a water jacket formed in the cylinder block 2.

[0095] The communications of the two inlet ports are established or blocked with 100°C as a boundary.

[0096] In a low temperature running condition with the cooling water temperature not higher than 80°C, as shown in Fig. 13, the cylinder head 3-side inlet port of the second thermostat 40 opens, while the cylinder block 2-side inlet port thereof is in a closed state, and the first thermostat 5 opens its cylinder head 3-side inlet port and closes its radiator 10-side inlet port.

[0097] Since the radiator 10 side of the first thermostat 5 is closed, there is no flow of cooling water to the radiator 10 via the second thermostat 40. Cooling water recycling from the cylinder head 3 passes through a bypass 7 without circulating through the radiator 10 and enters an inlet port 5c of the first thermostat 5, then is sucked into the water pump 4 from an outlet port 5d and most of the cooling water flows from a discharge port 4b of the pump to the cylinder head 3 through the joint 41 (thick solid-line arrows in Fig. 13), while a portion thereof flows to the cylinder block 2 (a thin solid-line arrow in Fig. 13), in parallel.

[0098] Consequently, it is possible to suppress the drop in temperature of the gas remaining in the combustion chamber. Besides, when the temperature is low, since cooling water is not only circulated directly to the cylinder head 3 but also is allowed to flow through the cylinder block 2 even in a small amount, there is no stay of cooling water in the cylinder block 2 and hence it is possible to suppress the drop in temperature of the residual gas in the combustion chamber more effectively.

[0099] When the cooling water temperature exceeds 80°C and is not higher than 100°C, as shown in Fig. 14, the first thermostat 5 closes its inlet port located on the cylinder head 3 side and opens the radiator 10 side, so that the cooling water which has gathered in the cylinder head 3 flows into the second.thermostat 40 from the open inlet port of the same thermostat, then flows to the radiator 10 from the outlet port, in which it is cooled. Then, the cooling water flows into the first thermostat 5 and most of the cooling water flows from the water pump 4 to the cylinder head 3 through the joint 41 (thick solid-line arrows in Fig. 14), while a portion thereof flows to the cylinder block 2 (a thin solid-line arrow in Fig. 14), in parallel.

[0100] Thus, most of the cooling water whose heat has been taken off during circulation through the radiator 10 and which has therefore become low in temperature flows directly to the cylinder head 3 (thick solid-line arrows in Fig. 14) and cools the combustion chamber positively.

[0101] A portion of cooling water also flows through the cylinder block 2 and an orifice to the cylinder head 3 (thin solid-line arrows in Fig. 14) and thus there is no stay of cooling water in the cylinder block 2.

[0102] Therefore, when the cylinder head 3 is to be cooled, it is possible to prevent a high-temperature cooling water staying in the cylinder block 2 from flowing to the cylinder head 3, obstructing cooling of the cylinder head 3 and causing knocking, which has occurred heretofore.

[0103] When the cooling water temperature further rises and exceeds 100°C, as shown in Fig. 15, the second thermostat 40 closes its cylinder head 3-side inlet port and opens its cylinder block 2-side inlet port, so that most of the cooling water which has flowed through the radiator 10 then flows from the joint 41 to the cylinder head 3 and further to the cylinder block 2 in series, while a portion of the cooling water flows directly to the cylinder block 2 through an orifice. The two flows gather in the water jacket of the cylinder block 2 and the thus-joined flow then flows through the second thermostat 40 and further circulates to the radiator 10.

[0104] A large amount of cooling water flows through not only the cylinder head 3 but also the cylinder block 2 and cools the whole of the internal combustion engine 1 positively, thereby preventing worsening of the knocking level.

[0105] Since the cooling water always enters the cylinder head 3 first, the temperature of the cooling water which cools the cylinder head 3 does not change even when switching is made from one to another flow path, thus ensuring a more powerful cooling for the cylinder head than before.

[0106] Thus, the flow of cooling water is controlled by two thermostats 5 and 40, particularly the flow of cooling water in the cylinder block 2 and the cylinder head 3 is controlled by the second thermostat 40. That is, it is not necessary to use a control unit and a drive unit, whereby it is possible to attain the simplification of structure and reduction of cost.

[0107] A description will be given below of a cooling structure for an internal combustion engine according to a further embodiment of the present invention.

[0108] Figs. 16 to 18 are block diagrams illustrating this cooling structure in three temperature conditions.

[0109] This embodiment is basically of the same construction as that of the embodiment illustrated above in Figs. 13 to 15 and is different only in that a first thermostat 50 is provided in a cooling water inlet of a radiator. The same principal components as in the said previous embodiment are identified by the same reference numerals.

[0110] A first thermostat 50 disposed in a cooling water inlet of a radiator 10 has valves in inlet ports communicating with a cylinder head 3 and a second thermo-

stat 40, respectively, and also has valves in outlet ports communicating with the radiator 10 and a water pump 4, the valves being adapted to open and close with a cooling water temperature of 80°C as a boundary.

[0111] The second thermostat 40 has valves in inlet ports communicating with water jackets formed in a cylinder head 3 and a cylinder block 2, respectively, the valves being adapted to open and close with 100°C as a boundary.

[0112] In a low-temperature running condition with the cooling water temperature not higher than 80°C, as shown in Fig. 16, the second thermostat 40 opens its cylinder head 3-sdie inlet port, with its cylinder block 2-side inlet port being in a closed state, while the first thermostat 50 opens its cylinder head 3-side inlet port, closes its inlet port located on the second thermostat 40 side, closes its radiator 10-side outlet port, and opens its water pump 4-side outlet port.

[0113] Cooling water recycling from the cylinder head 3 flows through the first thermostat 50 and is sucked into the water pump 4 without circulating through the radiator 10, and most of the cooling water flows from a discharge port 4b of the pump to the cylinder head 3 through a joint 41 (thick solid-line arrows in Fig. 16), while a portion thereof flows to the cylinder block 2 (a thin solid-line arrow in Fig. 16), in parallel.

[0114] Therefore, it is possible to suppress the drop in temperature of the gas remaining in the combustion chamber and there is no stay of cooling water in the cylinder block 2, whereby the drop in temperature of the residual gas in the combustion chamber can be suppressed more effectively.

[0115] When the cooling water temperature exceeds 80°C and is not higher than 100°C, as shown in Fig. 17, the first thermostat 50 closes the cylinder head 3-side inlet port and the water pump 4-side outlet port and opens the second thermostat 40-side inlet port and the radiator 10-side outlet port, so that the cooling water which has gathered in the cylinder head 3 flows into the second thermostat 40 from the open inlet port of the second thermostat, then flows out from the outlet port of the same thermostat into the radiator 10 through the first thermostat 50, and is cooled therein and sucked into the water pump 4, then most of the cooling water flows to the cylinder head 3 through the joint 41 (thick solid-line arrows in Fig. 17), while a portion thereof flows to the cylinder block 2 (a thin solid-line arrow in Fig. 17), in parallel.

[0116] Thus, most of the cooling water whose heat has been taken off during circulation in the radiator 10 and which has therefore become low in temperature flows directly to the cylinder head 3 (a thick solid-line arrow in Fig. 17) and cools the combustion chamber positively.

[0117] A portion of cooling water also flows through the cylinder block 2 and an orifice to the cylinder head 3 (thin solid-line arrows in Fig. 17) and thus there is no stay of cooling water in the cylinder block 2.

[0118] Therefore, when the cylinder head 3 is to be cooled, it is possible to prevent a high-temperature cooling water staying in the cylinder block 2 from flowing to the cylinder head 3, obstructing cooling of the cylinder head 3 and causing knocking, which has occurred heretofore.

[0119] When the cooling water temperature further rises and exceeds 100°C, as shown in Fig. 18, the second thermostat 40 closes its cylinder head 3-side inlet port and opens its cylinder block 2-side inlet port, so that most of the cooling water which has passed through the radiator 10 flows from the joint 41 to the cylinder head 3 and thence the cylinder block 2 in series, while a portion thereof flows directly to the cylinder block 2 through an orifice. The two flows gather in the water jacket of the cylinder block 2 and the thus-joined flow then flows through the second thermostat 40, further through the first thermostat 50, and circulates to the radiator 10.

[0120] A large amount of cooling water flows through not only the cylinder head 3 but also the cylinder block 2 and cools the whole of the internal combustion engine 1 positively, thus preventing worsening of the knocking level.

[0121] Since the cooling water flows into the cylinder head 3 first, the temperature of the cooling water which cools the cylinder head 3 does not change even if switching is made from one to another flow path, thus permitting the cylinder head to be cooled more powerfully than before.

[0122] Thus, the flow of cooling water is controlled by two thermostats 40 and 50 without the need of using a control unit and a drive unit, whereby it is possible to attain the simplification of structure and the reduction of cost.

[0123] In summary it is an object to provide less expensively a cooling structure for an internal combustion engine which, despite a simple structure, can control the flow of coolant to a cylinder and a cylinder head without allowing the coolant to stay in the cylinder, according to the temperature of the coolant, and which can expect the attainment of both the effect of suppressing a drop in temperature of residual gas and an anti-knocking effect.

[0124] It is provided a cooling structure for an internal combustion, comprising a first coolant circulation system and a second coolant circulation system, the first coolant circulation system having a first thermostat 5 for adjusting the amount of coolant to be circulated between a radiator 10 and the internal combustion engine, the second coolant circulation system having a second thermostat 20, the second thermostat 20 making control so that the coolant circulates in parallel to a cylinder 2 and a cylinder head 3 when the temperature of the coolant is lower than a predetermined coolant temperature, while when the coolant temperature is higher than the predetermined coolant temperature, the coolant circulates in series from the cylinder 2 to the cylinder head 3.

Claims

1. A cooling structure for an internal combustion engine (1), comprising:

   a first coolant circulation system provided with a first thermostat (5;30) for adjusting the amount of coolant to be circulated between a radiator (10) and the internal combustion engine (1); and

   a second coolant circulation system, **characterized in that** the second coolant circulation system is provided with a second thermostat (20), said second thermostat (20) making control so that the coolant circulates in parallel to a cylinder (2) and a cylinder head (3) when the temperature of the coolant is lower than a predetermined coolant temperature, while when the coolant temperature is higher than the predetermined coolant temperature, the coolant circulates in series from the cylinder (2) to the cylinder head (3).

2. A cooling structure for an internal combustion engine (1) according to claim 1, wherein when the coolant circulates in parallel to the cylinder (2) and the cylinder head (3) while being controlled by the second thermostat (20) in said second coolant circulation system, most of the coolant flows directly to the cylinder head (3) and the remaining portion of the coolant flows to the cylinder (2).

3. A cooling structure for an internal combustion engine according to claim 1 or claim 2, wherein a valve operating temperature in the second thermostat (20) is set higher than that in the first thermostat (5; 30).

4. A cooling structure for an internal combustion engine according to any of claims 1 to 3, wherein in each of the first (5;30) and second (20) thermostats a valve element (5a;22,23) is actuated in accordance with expansion and contraction of wax contained in a temperature sensing portion (5a;21a) which is for detecting the temperature of the circulating coolant.

5. A cooling structure for an internal combustion engine according to any of claims 1 to 4, wherein said first thermostat (5) is disposed between a coolant outlet (10b) of the radiator (10) and the internal combustion engine (1).

6. A cooling structure for an internal combustion engine according to any of claims 1 to 4, wherein said first thermostat (30) is disposed between a coolant inlet of the radiator (10) and the internal combustion engine (1).

7. A cooling structure for an internal combustion engine (1), comprising:

   a first coolant circulation system provided with a first thermostat (5;50) for adjusting the amount of coolant to be circulated between a radiator (10) and the internal combustion engine (1); and
   a second coolant circulation system, **characterized in that** the second coolant circulation system is provided with a second thermostat (40), said second thermostat (40) making control so that the coolant circulates in parallel to a cylinder (2) and a cylinder head (3) when the temperature of the coolant is lower than a predetermined coolant temperature, while when the coolant temperature is higher than the predetermined coolant temperature, the coolant circulates in series from the cylinder head (3) to the cylinder (2).

8. A cooling structure for an internal combustion engine according to claim 7, wherein a valve operating temperature in the second thermostat (40) is set higher than that in the first thermostat (5;50).

9. A cooling structure for an internal combustion engine according to claim 8, wherein said first (5) thermostat is disposed between a coolant outlet of the radiator (10) and the internal combustion engine (1).

10. A cooling structure for an internal combustion engine according to claim 9, further including a branching means (41) for branching the flow of the coolant so that most of the coolant is fed to said cylinder head (3) and the remaining coolant is fed to said cylinder (2), and wherein said second thermostat (40) is disposed between a coolant inlet of the radiator (10) and the internal combustion engine (1), and when the coolant temperature is lower than the predetermined temperature, the second thermostat (40) opens a valve disposed on the cylinder head (3) side to let the coolant circulate in parallel to the cylinder (2) and the cylinder head (3), while when the coolant temperature is higher than the predetermined temperature, the second thermostat (40) closes the cylinder head (3) side valve and opens a cylinder (2) side valve to let the coolant circulate in series from the cylinder head (3) to the cylinder (2).

Patentansprüche

1. Kühlungsanordnung für eine Verbrennungskraft-

maschine (1), umfassend:

ein erstes Kühlmittelkreislaufsystem, das mit einem ersten Thermostaten (5; 30) versehen ist, um die Menge an Kühlmittel, die zwischen einem Kühler (10) und der Verbrennungskraftmaschine (1) zirkulieren soll, einzustellen;
ein zweites Kühlmittelkreislaufsystem, **dadurch gekennzeichnet, dass** das zweite Kühlmittelkreislaufsystem mit einem zweiten Thermostaten (20) versehen ist, der eine Steuerung so durchführt, dass das Kühlmittel parallel zu einem Zylinder (2) und zu einem Zylinderkopf (3) zirkuliert, wenn die Temperatur des Kühlmittels niedriger als eine vorgegebene Kühlmitteltemperatur ist, während dann, wenn die Kühlmitteltemperatur höher als die vorgegebene Kühlmitteltemperatur ist, das Kühlmittel der Reihe nach vom Zylinder (2) zum Zylinderkopf (3) zirkuliert.

2. Kühlungsanordnung für eine Verbrennungskraftmaschine (1) nach Anspruch 1, bei der dann, wenn das Kühlmittel parallel zum Zylinder (2) und zum Zylinderkopf (3) zirkuliert, während es vom zweiten Thermostaten (20) im zweiten Kühlmittelkreislaufsystem gesteuert wird, ein Großteil des Kühlmittels direkt zum Zylinderkopf (3) strömt und der restliche Anteil des Kühlmittels zum Zylinder (2) strömt.

3. Kühlungsanordnung für eine Verbrennungskraftmaschine nach Anspruch 1 oder Anspruch 2, bei der eine Ventilbetätigungstemperatur im zweiten Thermostaten (20) höher eingestellt ist als diejenige im ersten Thermostaten (5; 30).

4. Kühlungsanordnung für eine Verbrennungskraftmaschine nach irgendeinem der Ansprüche 1 bis 3, bei der in jedem der ersten (5; 30) und zweiten (20) Thermostate ein Ventilelement (50; 22, 23) entsprechend einer Expansion und Kontraktion eines Wachses betätigt wird, das in einem Temperaturerfassungsabschnitt (5a; 21a) enthalten ist, der zum Erfassen der Temperatur des zirkulierenden Kühlmittels dient.

5. Kühlungsanordnung für eine Verbrennungskraftmaschine nach irgendeinem der Ansprüche 1 bis 4, bei der der erste Thermostat (5) zwischen einem Kühlmittelauslass (10b) des Kühlers (10) und der Verbrennungskraftmaschine (1) angeordnet ist.

6. Kühlungsanordnung für eine Verbrennungskraftmaschine nach irgendeinem der Ansprüche 1 bis 4, bei der der erste Thermostat (30) zwischen einem Kühlmitteleinlass des Kühlers (10) und der Verbrennungskraftmaschine (1) angeordnet ist.

7. Kühlungsanordnung für eine Verbrennungskraftmaschine (1) umfassend:

ein erstes Kühlmittelkreislaufsystem, das mit einem ersten Thermostaten (5; 50) versehen ist, um die Menge an Kühlmittel, die zwischen einem Kühler (10) und der Verbrennungskraftmaschine (1) zirkulieren soll, einzustellen; und
ein zweites Kühlmittelkreislaufsystem, **dadurch gekennzeichnet, dass** das zweite Kühlmittelkreislaufsystem mit einem zweiten Thermostaten (40) versehen ist, der eine Steuerung so durchführt, dass das Kühlmittel parallel zu einem Zylinder (2) und zu einem Zylinderkopf (3) zirkuliert, wenn die Temperatur des Kühlmittels niedriger als eine vorgegebene Kühlmitteltemperatur ist, während dann, wenn die Kühlmitteltemperatur höher als die vorgegebene Kühlmitteltemperatur ist, das Kühlmittel der Reihe nach vom Zylinderkopf (3) zum Zylinder (2) zirkuliert.

8. Kühlungsanordnung für eine Verbrennungskraftmaschine nach Anspruch 7, bei der eine Ventilbetätigungstemperatur im zweiten Thermostaten (40) höher eingestellt ist als diejenige im ersten Thermostaten (5; 50).

9. Kühlungsanordnung für eine Verbrennungskraftmaschine nach Anspruch 8, bei der der erste Thermostat (5) zwischen einem Kühlmittelauslass des Kühlers (10) und der Verbrennungskraftmaschine (1) angeordnet ist.

10. Kühlungsanordnung für eine Verbrennungskraftmaschine nach Anspruch 9, die ferner ein Verzweigungsmittel (41) enthält zum Verzweigen der Strömung des Kühlmittels, derart, dass ein Großteil des Kühlmittels dem Zylinderkopf (3) zugeführt wird und das restliche Kühlmittel dem Zylinder (2) zugeführt wird, wobei der zweite Thermostat (40) zwischen einem Kühlmitteleinlass des Kühlers (10) und der Verbrennungskraftmaschine (1) angeordnet ist, und wobei dann, wenn die Kühlmitteltemperatur niedriger als die vorgegebene Temperatur ist, der zweite Thermostat (40) ein auf der Seite des Zylinderkopfes (3) angeordnetes Ventil öffnet, um das Kühlmittel parallel zum Zylinder (2) und zum Zylinderkopf (3) zirkulieren zu lassen, während dann, wenn die Kühlmitteltemperatur höher als die vorgegebene Temperatur ist, der zweite Thermostat (40) das Ventil auf der Seite des Zylinderkopfes (3) schließt und ein Ventil auf der Seite des Zylinders (2) öffnet, um das Kühlmittel der Reihe nach vom Zylinderkopf (3) zum Zylinder (2) zirkulieren zu lassen.

Revendications

1. Une structure de refroidissement pour un moteur à combustion interne (1), comprenant :

   un premier système de circulation de fluide de refroidissement, muni d'un premier thermostat (5 ; 30) pour ajuster la quantité de fluide de refroidissement à mettre en circulation entre un radiateur (10) et le moteur à combustion interne (1) ; et
   un deuxième système de circulation de fluide de refroidissement, **caractérisé en ce que** le deuxième système de circulation de fluide de refroidissement est muni d'un deuxième thermostat (20), ledit deuxième thermostat (20) assurant une commande de manière que le fluide de refroidissement circule en parallèle vers un cylindre (2) et une culasse (3) lorsque la température du fluide de refroidissement est inférieure à une température de fluide de refroidissement prédéterminée, tandis que lorsque la température du fluide de refroidissement est supérieure à la température prédéterminée de fluide de refroidissement, le fluide de refroidissement circule en série, du cylindre (2) à la culasse (3).

2. Une structure de refroidissement pour un moteur à combustion interne (1) selon la revendication 1, dans laquelle, lorsque le fluide de refroidissement circule en parallèle vers le cylindre (2) et vers la culasse, tout en étant commandé par le deuxième thermostat (20) dans ledit deuxième système de circulation de fluide de refroidissement, la majeure partie de l'écoulement de fluide de refroidissement va directement à la culasse (3) et la partie restante du fluide de refroidissement va au cylindre (2).

3. Une structure de refroidissement pour un moteur à combustion interne selon la revendication 1 ou la revendication 2, dans laquelle une température de fonctionnement de soupape, dans le deuxième thermostat (20), est réglée à une valeur supérieure à celle qu'on a dans le premier thermostat (5 ; 30).

4. Une structure de refroidissement pour un moteur à combustion interne selon l'une quelconque des revendications 1 à 3, dans laquelle, dans chacun des premiers (5 ; 30) et deuxième (20) thermostat, un élément de soupape (5a ; 22, 23) est actionné, en fonction de l'expansion et de la contraction d'une cire contenue dans une partie de détection de température (5a ; 21a) servant à détecter la température du fluide de refroidissement mis en circulation.

5. Une structure de refroidissement pour un moteur à combustion interne selon l'une quelconque des revendications 1 à 4, dans laquelle le premier thermostat (5) est disposé entre une sortie de fluide de refroidissement (10b) du radiateur (10) et le moteur à combustion interne (1).

6. Une structure de refroidissement pour un moteur à combustion interne selon l'une quelconque des revendications 1 à 4, dans laquelle ledit premier thermostat (30) est disposé entre une entrée de fluide de refroidissement du radiateur (10) et le moteur à combustion interne (1).

7. Une structure de refroidissement pour un moteur à combustion interne (1), comprenant :

   un premier système de circulation de fluide de refroidissement, muni d'un premier thermostat (5 ; 50) pour ajuster la quantité de fluide de refroidissement à faire circuler entre un radiateur (10) et le moteur à combustion interne (1) ; et
   un deuxième système de circulation de fluide de refroidissement, **caractérisé en ce que** le deuxième système de circulation de fluide de refroidissement est muni d'un deuxième thermostat (40), ledit deuxième thermostat (40) effectuant une commande de manière que le fluide de refroidissement circule en parallèle vers un cylindre (2) et une culasse (3), lorsque la température du fluide de refroidissement est inférieure à une température prédéterminée de fluide de refroidissement, tandis que le fluide de refroidissement circule en série de la culasse (3) au le cylindre (2), lorsque la température du fluide de refroidissement est supérieure à la température prédéterminée de fluide de refroidissement.

8. Une structure de refroidissement pour un moteur à combustion interne selon la revendication 7, dans laquelle une température d'actionnement de soupape dans le deuxième thermostat (40) est fixée à une valeur supérieure à celle qu'on a dans le premier thermostat (5 ; 50).

9. Une structure de refroidissement pour un moteur à combustion interne selon la revendication 8, dans laquelle ledit premier thermostat (5) est disposé entre une sortie de fluide de refroidissement du radiateur et le moteur à combustion interne (1).

10. Une structure de refroidissement pour un moteur à combustion interne selon la revendication 9, comprenant en outre des moyens de branchement (41) pour faire bifurquer l'écoulement du fluide de refroidissement, de manière que la majeure partie du fluide de refroidissement soit fournie à ladite culasse (3) et que le fluide de refroidissement restant soit fourni audit cylindre (2), et dans laquelle ledit

deuxième thermostat (40) est disposé entre une entrée de fluide de refroidissement du radiateur (10) et le moteur à combustion interne (1) et, lorsque la température de fluide de refroidissement est inférieure à la température prédéterminée, le deuxième thermostat (40) ouvre une soupape disposée sur le côté de la culasse (3), pour laisser circuler le fluide de refroidissement en parallèle vers le cylindre (2) et la culasse (3), tandis que, lorsque la température de fluide de refroidissement est supérieure à la température prédéterminée, le deuxième thermostat (40) ferme la soupape située du côté de la culasse (3) et ouvre la soupape située du côté du cylindre (2), pour faire circuler le fluide de refroidissement en série, de la culasse (3) vers le cylindre (2).

FIG. 1

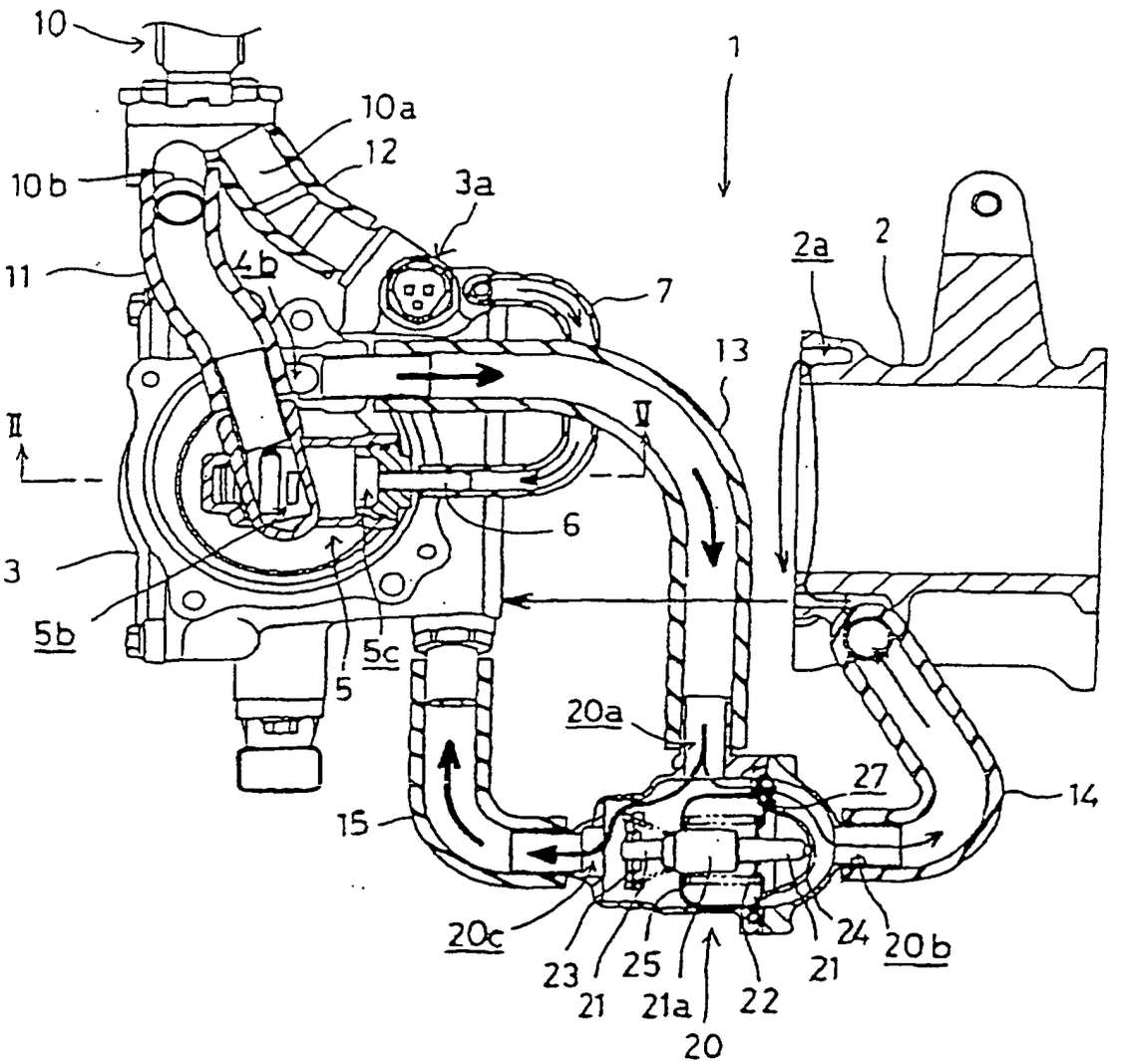

10
10a
12
10b
3a
11
4b
7
1
2a
2
13
II
II
6
3
5b
5c
5
20a
27
14
15
20c
23
21
25
21a
22
20
21
24
20b

FIG. 2

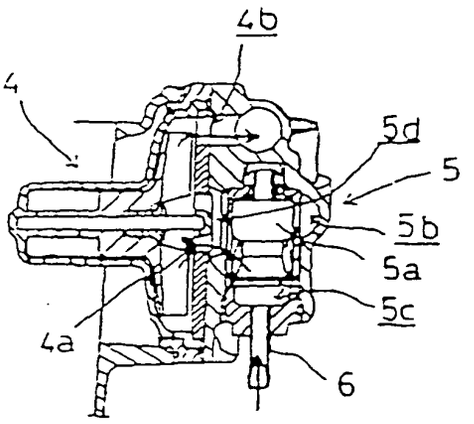

4b
4
5d
5
5b
5a
5c
4a
6

FIG. 3

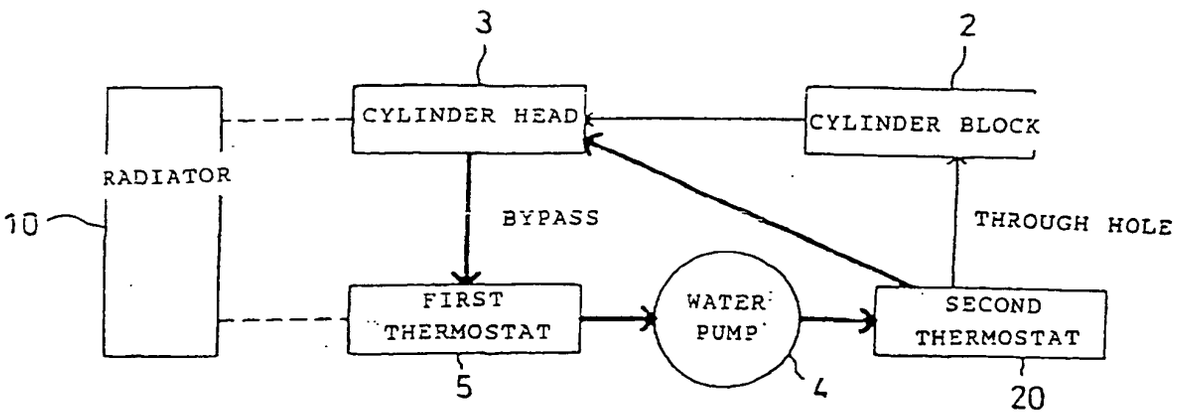

3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
BYPASS
THROUGH HOLE
FIRST THERMOSTAT
WATER PUMP
SECOND THERMOSTAT
5
4
20

FIG. 4

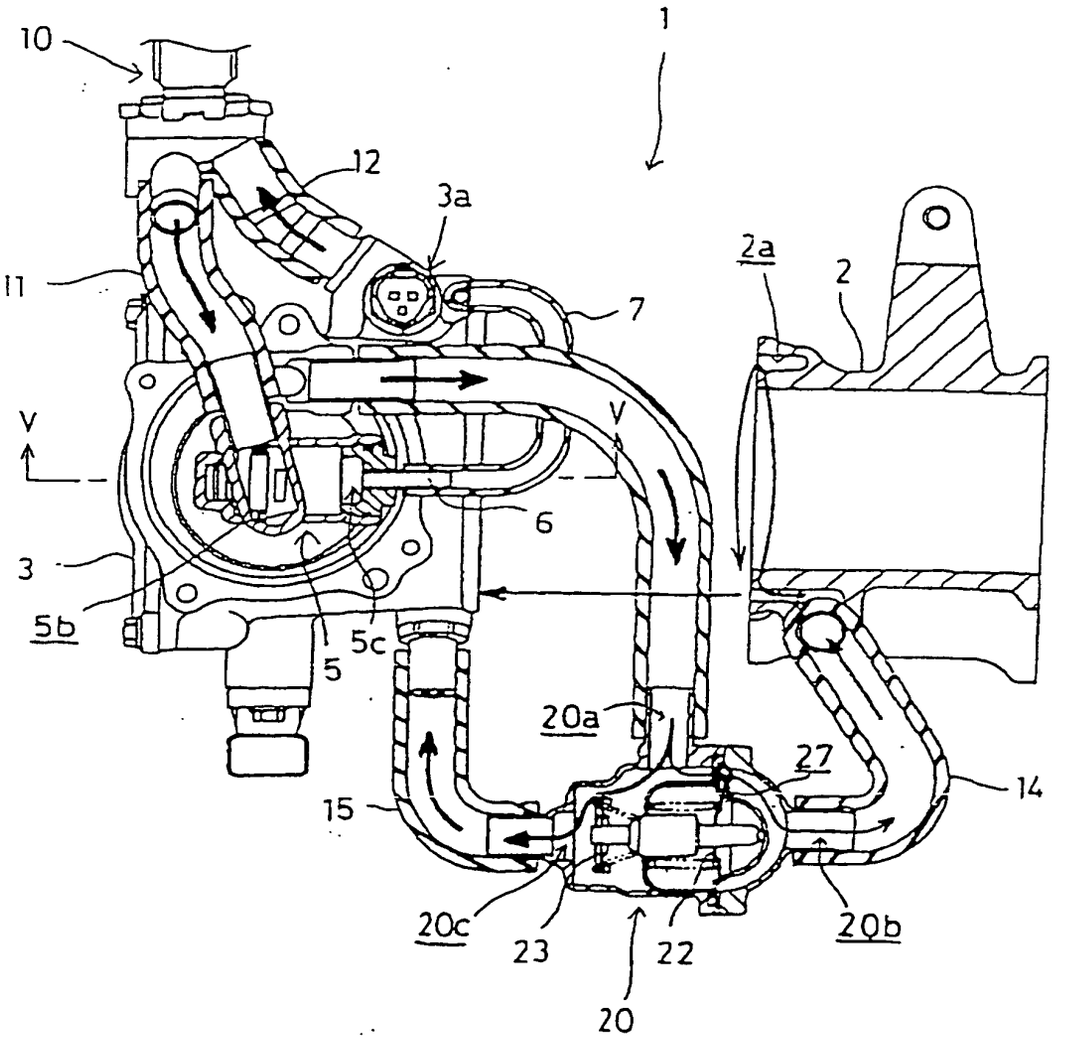


FIG. 5

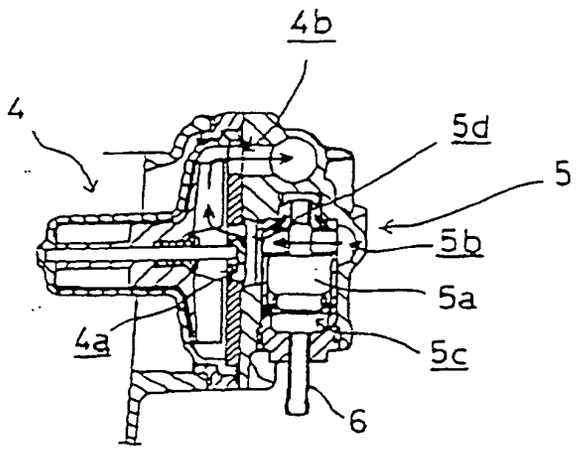

4b
4
5d
5
5b
5a
4a
5c
6

FIG. 6

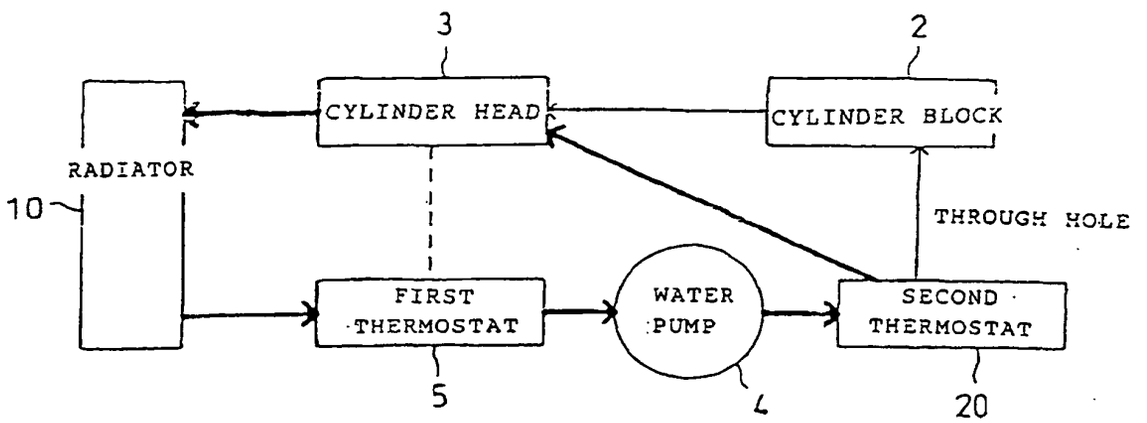

3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
THROUGH HOLE
FIRST THERMOSTAT
WATER PUMP
SECOND THERMOSTAT
5
4
20

FIG. 7

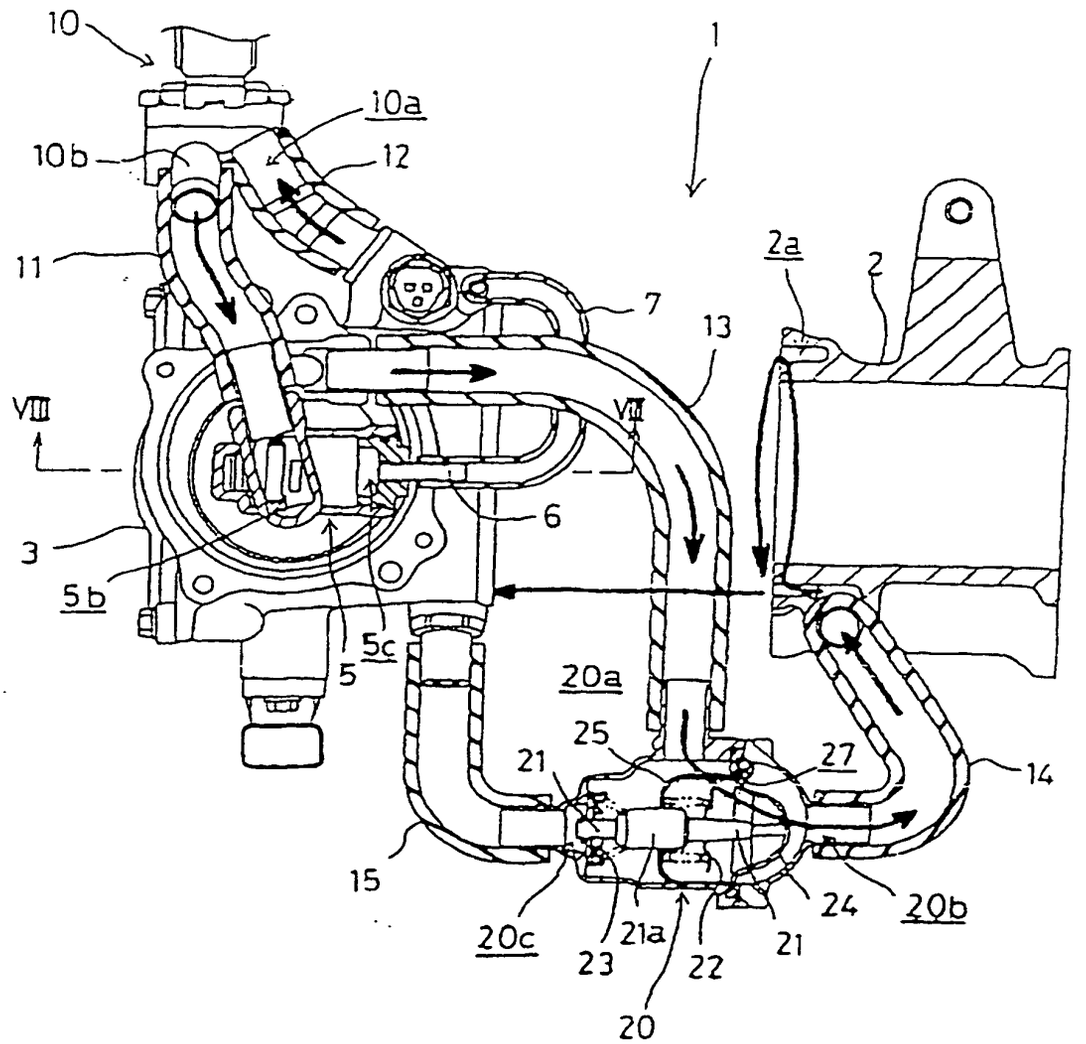

10
1
10a
10b
12
11
2a
2
7
13
VIII
VII
6
3
5b
5c
5
20a
25
21
27
14
15
20c
23
21a
22
21
24
20b
20

FIG. 8

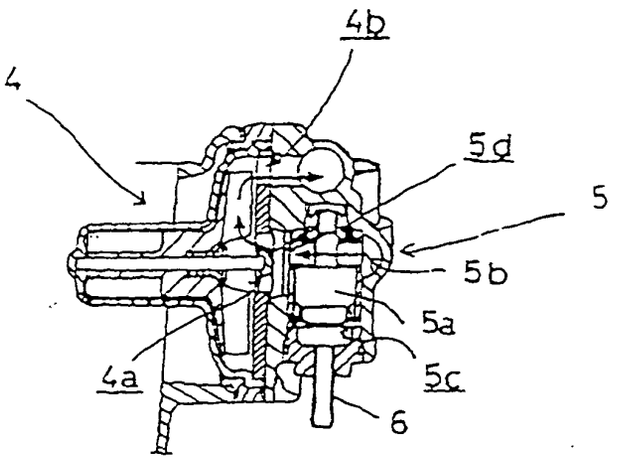

4b
4
5d
5
5b
5a
4a
5c
6

FIG. 9

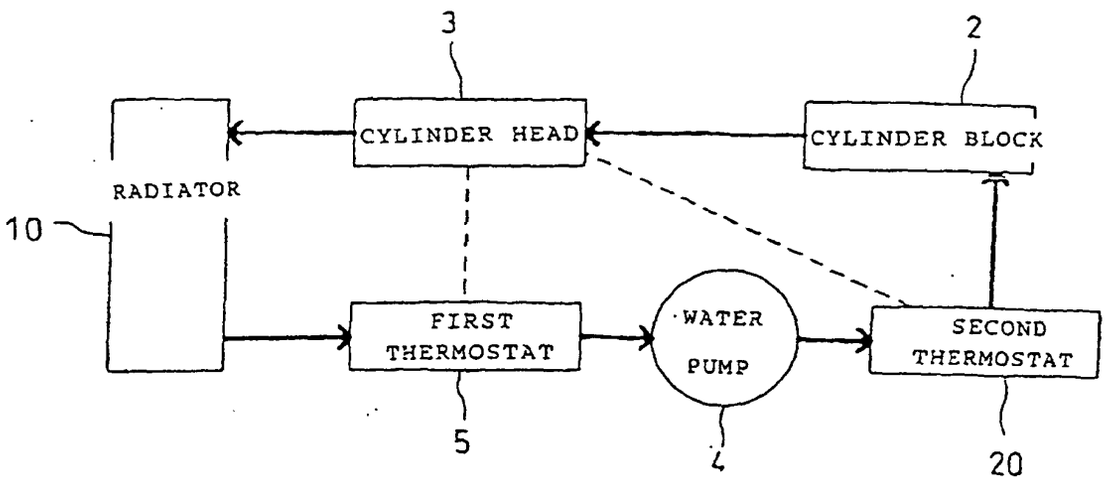

3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
FIRST THERMOSTAT
WATER PUMP
SECOND THERMOSTAT
5
4
20

FIG. 10

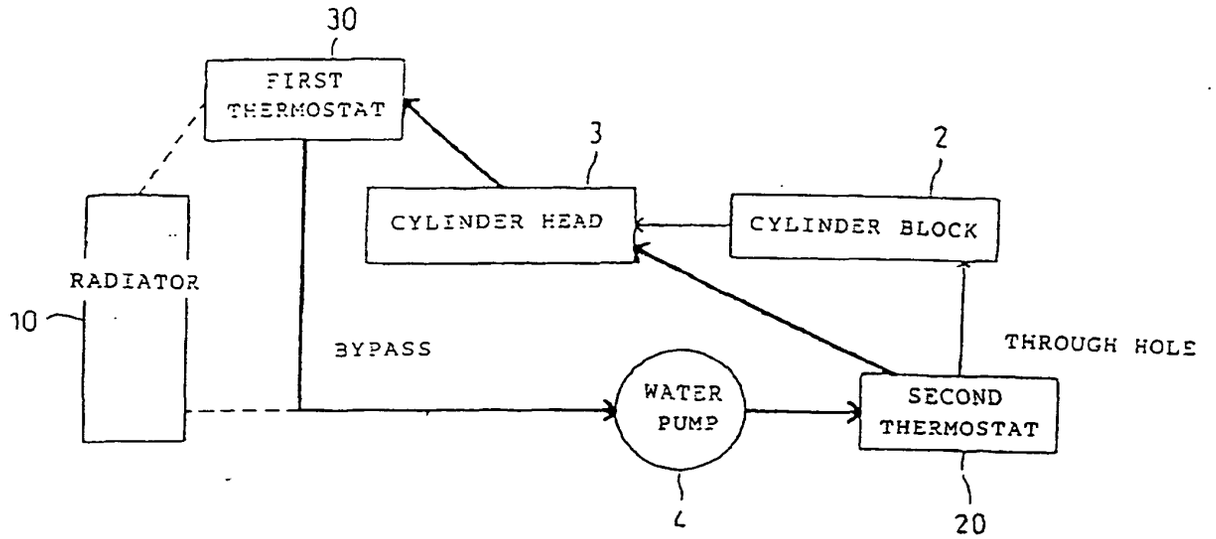

30
FIRST THERMOSTAT
3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
BYPASS
THROUGH HOLE
WATER PUMP
SECOND THERMOSTAT
4
20

FIG. 11

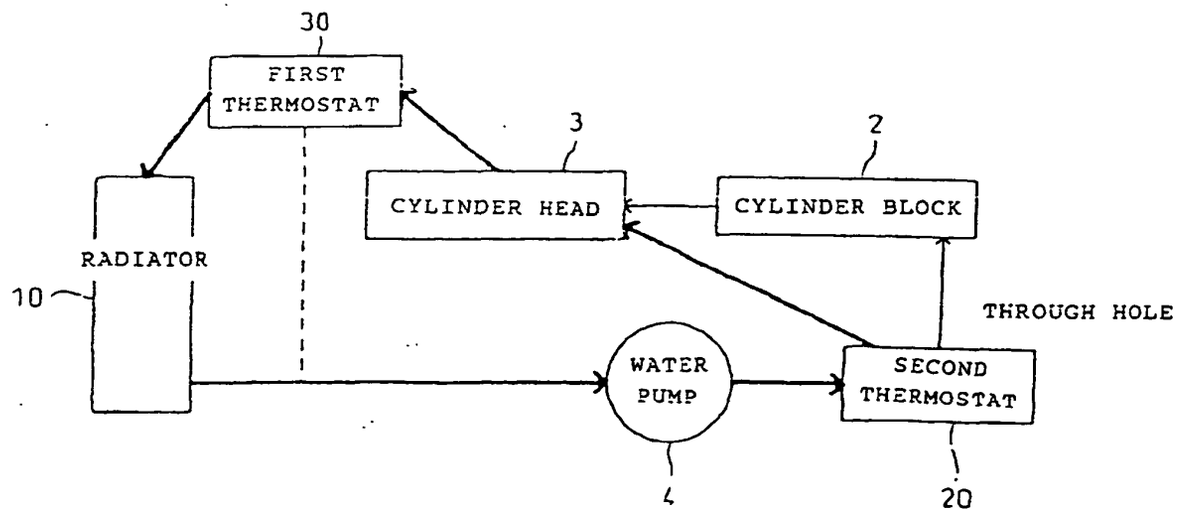

30
FIRST THERMOSTAT
3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
THROUGH HOLE
WATER PUMP
SECOND THERMOSTAT
4
20

FIG. 12

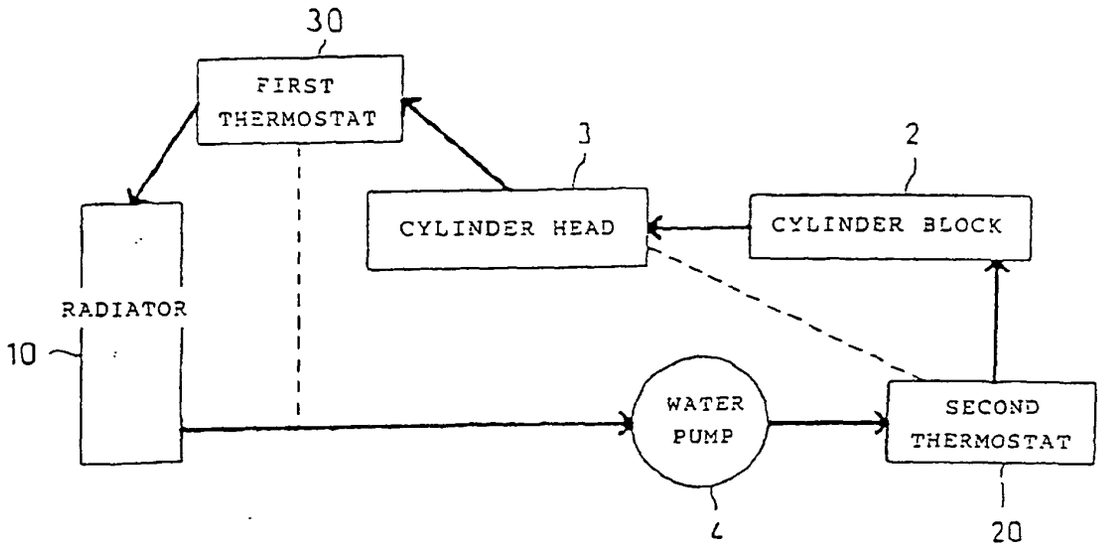

30
FIRST THERMOSTAT
3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
WATER PUMP
SECOND THERMOSTAT
4
20

FIG. 13

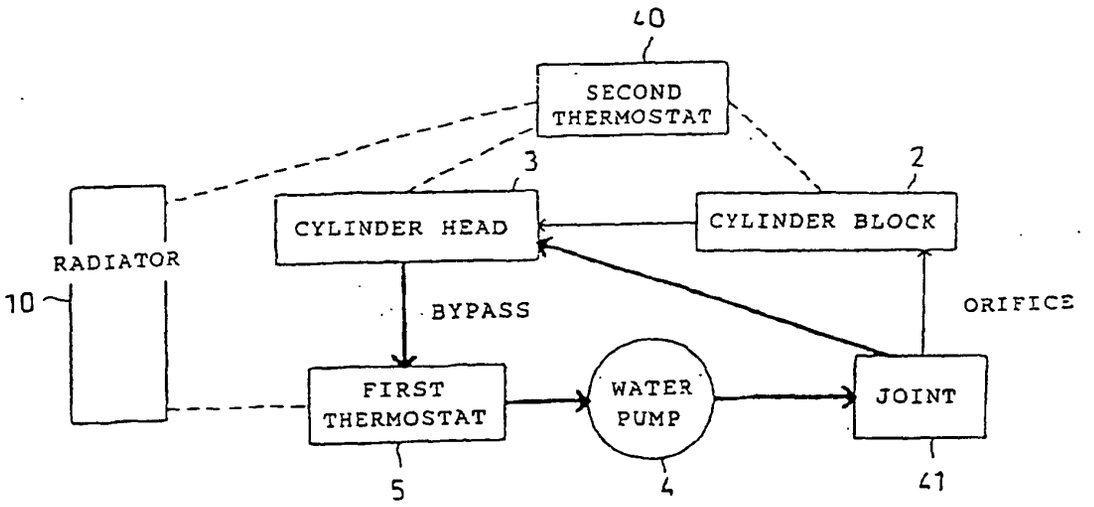

40
SECOND THERMOSTAT
3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
BYPASS
ORIFICE
FIRST THERMOSTAT
WATER PUMP
JOINT
5
4
41

FIG. 14

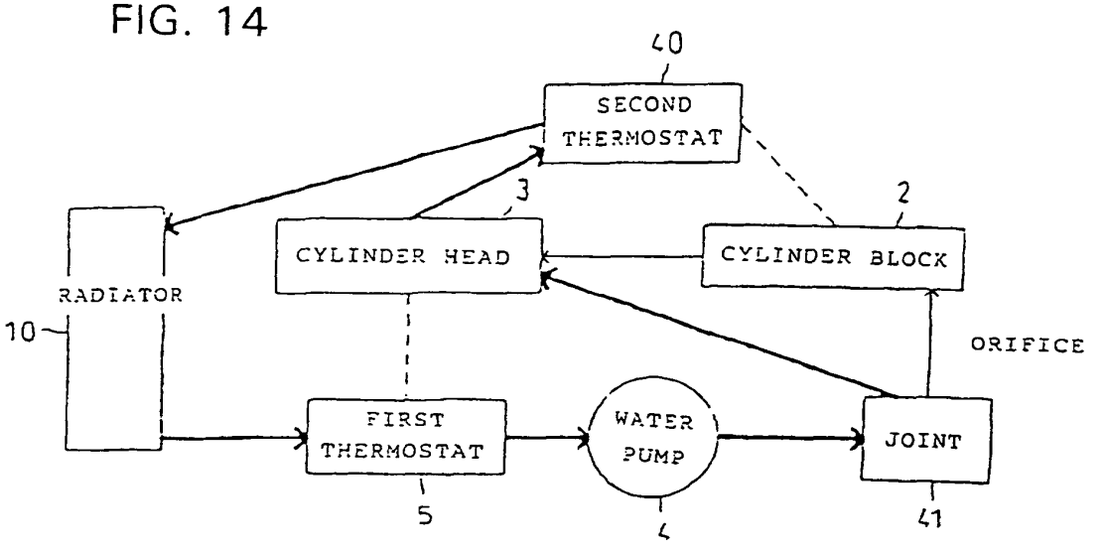

40
SECOND THERMOSTAT
3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
ORIFICE
FIRST THERMOSTAT
WATER PUMP
JOINT
5
4
41

FIG. 15

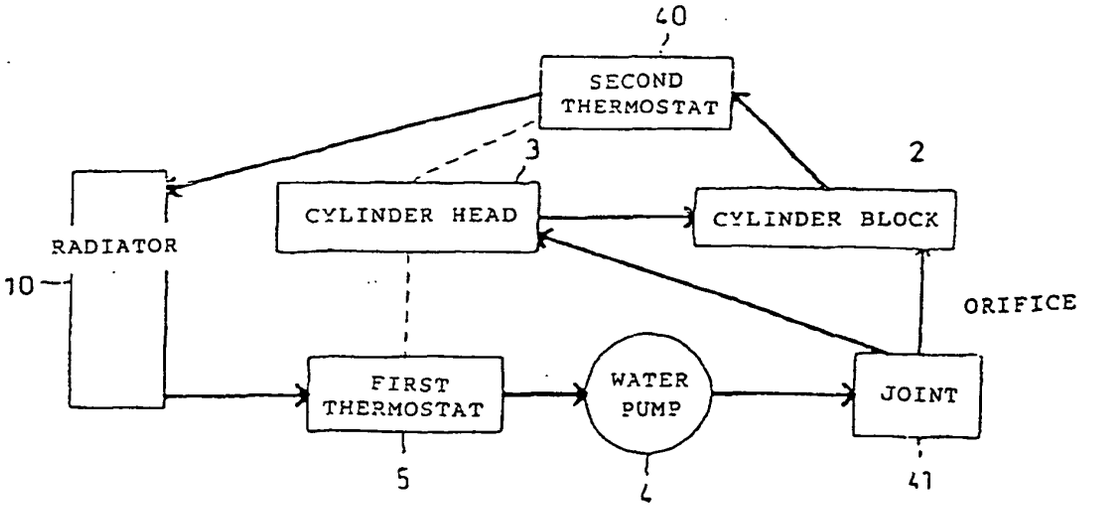

40
SECOND THERMOSTAT
3
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
ORIFICE
FIRST THERMOSTAT
WATER PUMP
JOINT
5
4
41

FIG. 16

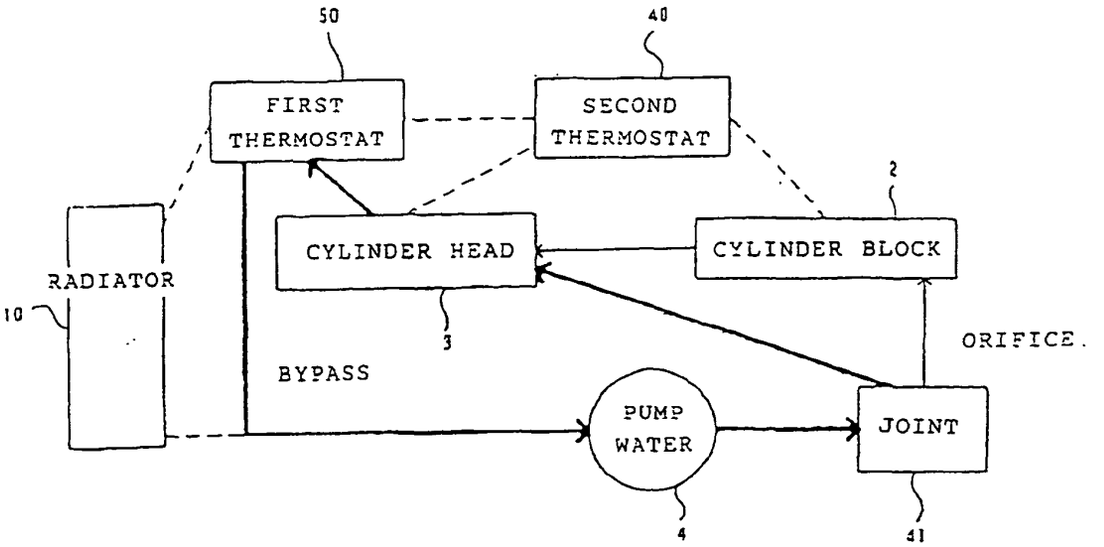

50
40
FIRST THERMOSTAT
SECOND THERMOSTAT
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
3
ORIFICE
BYPASS
PUMP WATER
JOINT
4
41

FIG. 17

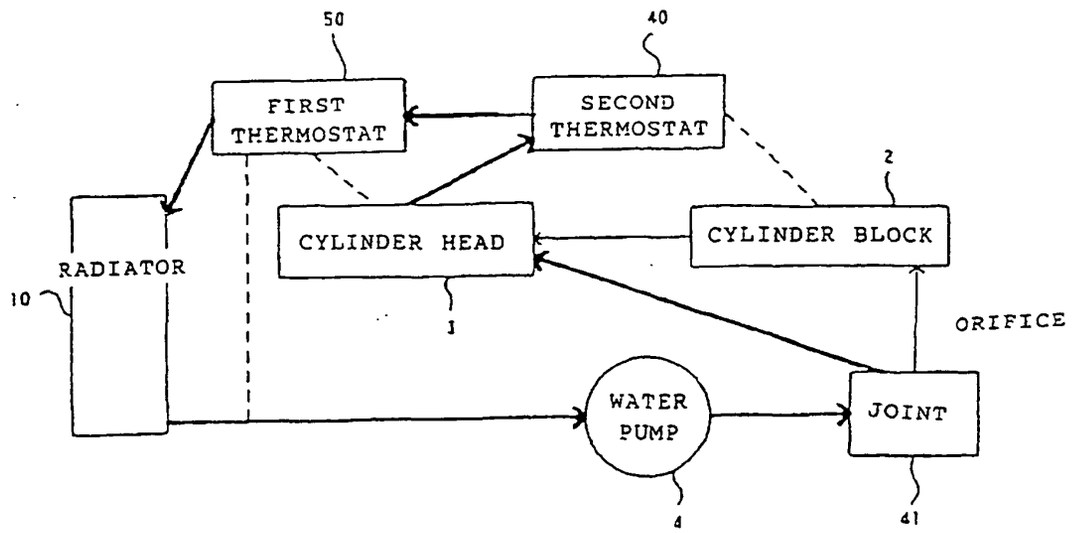

50
40
FIRST THERMOSTAT
SECOND THERMOSTAT
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
3
ORIFICE
WATER PUMP
JOINT
4
41

FIG. 18

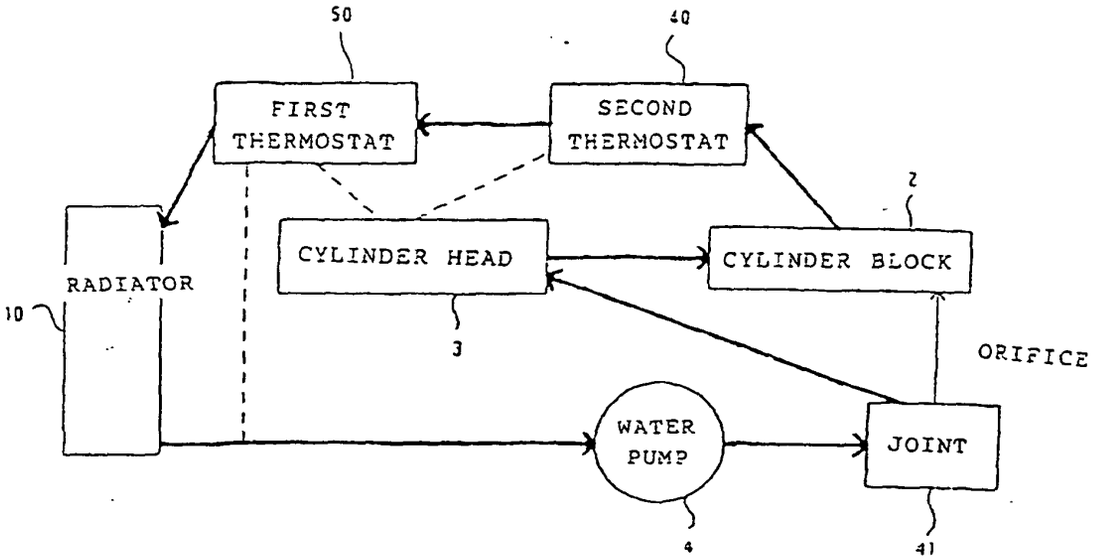
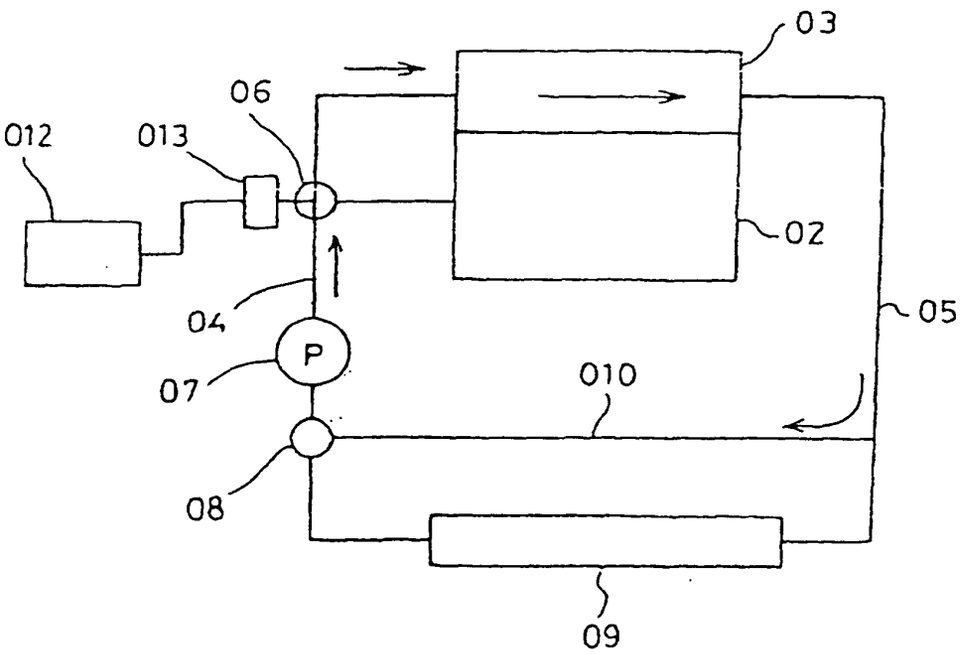

50
40
FIRST THERMOSTAT
SECOND THERMOSTAT
2
CYLINDER HEAD
CYLINDER BLOCK
RADIATOR
10
3
ORIFICE
WATER PUMP
JOINT
4
41

FIG. 19


03
06
012
013
02
04
05
P
07
010
08
09