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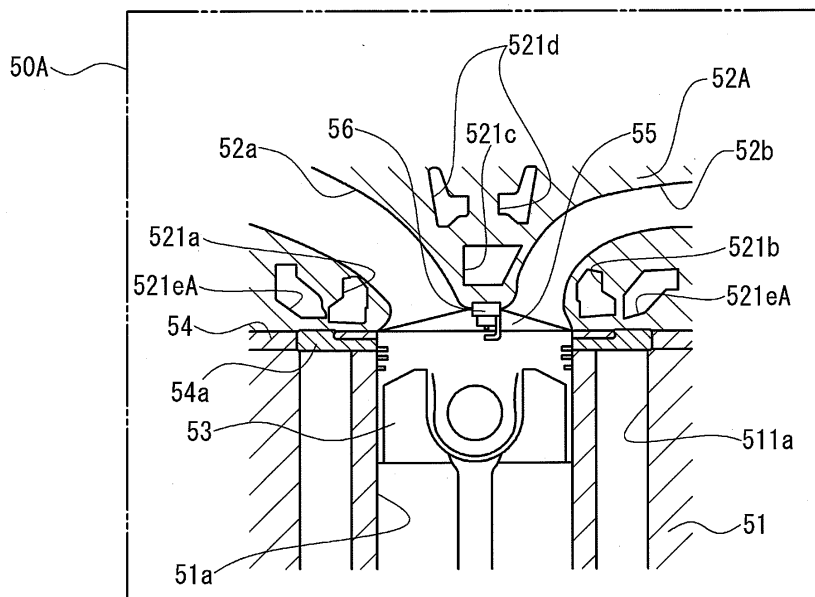
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(54) **COOLING DEVICE FOR ENGINE**

(57) A cooling device 1A for engine includes: an engine 50A having a cylinder block 51, a cylinder head 52A and a gasket 54, the gasket 54 being provided between the cylinder block 51 and the cylinder head 52A and having a high thermal conductivity member 54a allowing heat transfer between an upper part of a cylinder 51a and the

cylinder head 52A with a heat transfer rate higher than the other part, a partial W/J 521eA being provided around the high thermal conductivity member 54a; and an ECU 70A performing a control for changing flow condition of cooling medium flowing in the partial W/J 521eA, according to combustion engine operation condition.

FIG. 2



Description

TECHNICAL FIELD

[0001] The present invention relates to a cooling device for engine.

BACKGROUND ART

[0002] Conventionally, in general, cooling with cooling water is performed in an engine. And, conventionally, it is known that knocking tends to occur at an outer circumference portion of a combustion chamber (end gas area) in the engine, especially in a spark-ignited internal combustion engine. In this point, for example, as a technology for restraining occurrence of knocking, Patent Document 1 discloses a cooling device of a combustion engine in which a heat-transfer member made of a material having heat-transfer rate higher than a cylinder block is provided between an upper part of a cylinder liner and a part of which temperature is lower than the upper part of the cylinder liner. And, for example, Patent Document 2 discloses a cooling structure of a combustion engine having a ring-shaped member that is provided between an upper face of a cylinder and a lower face of a cylinder head, is formed concentrically with the cylinder, has an inner circumference face exposed to a combustion chamber, and has a heat-transfer rate higher than a head gasket.

PRIOR ART DOCUMENTS

[0003]

Patent Document 1: Japanese Utility Model Application Publication No. 6-43241; and
Patent Document 2: Japanese Patent Application Publication No. 2009-144652.

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] By the way, as illustrated in FIG. 13, in an engine, especially in a spark-ignited internal combustion engine, much heat not used for net work such as emission loss or cooling loss is generated. Reduction of the cooling loss occupying a large ratio of whole energy loss is very important element for improving thermal efficiency (fuel consumption). However, it is not always easy to reduce the cooling loss and use the heat effectively. This results in prevention of improvement of thermal efficiency.

[0005] For example, a normal engine does not have a structure for locally changing the heat transfer condition, as a reason that the reduction of cooling loss is difficult. That is, with a normal engine, it is difficult to cool a part needing cooling by only necessary degree. In concrete, the flow amount of cooling water is changed according to an engine rotation frequency by a mechanical water

pump driving with an output of the engine, when changing the heat transfer condition of the engine. However, the water pump adjusting the flow amount of the cooling water in whole cannot locally change the heat transfer condition according to the combustion engine operation condition even if a variable water pump capable of changing the flow amount is used.

[0006] It is also thought that thermal insulating property of the engine is increased, when reducing the cooling loss. And in this case, a great reduction of the cooling loss illustrated in FIG. 14 is expected. However, in this case, the temperature of the inner wall of the combustion chamber is increased when the thermal insulating property of the engine is increased. And in this case, there is a problem that a knocking is induced because of the increasing of the temperature of mixed air with this event.

[0007] On the other hand, the technology disclosed in Patent Documents 1 and 2 mentioned above restrains the occurrence of the knocking by letting heat of an end gas area out to the cylinder head and so on. However, in the disclosed technologies, heat is eventually transferred. That is, these disclosed technologies have a problem that proper heat transfer is not always occurred in view of restraining of the occurrence of the knocking in addition to improving the thermal efficiency.

[0008] Therefore, in view of the problem described above, it is an object of the present invention to provide a cooling device for engine that is capable of restraining occurrence of knocking by locally changing heat transfer condition of an engine with a reasonable condition and is further capable of preferably achieving reduction of cooling loss and knocking performance.

MEANS FOR SOLVING THE PROBLEMS

[0009] The present invention for solving the above-mentioned problem is a cooling device for engine including: an engine having a cylinder block, a cylinder head, and a gasket, the gasket being provided between the cylinder block and the cylinder head and having a heat transfer allowing portion allowing heat transfer between an upper part of a cylinder of the cylinder block and the cylinder head with a heat transfer rate higher than the other part, a cooling medium pathway being provided around the heat transfer allowing portion in the cylinder head; and a control portion performing a control for changing flow condition of cooling medium flowing in the cooling medium pathway, according to combustion engine operation condition.

[0010] And, the present invention is preferable if the control portion performs a control for promoting heat transfer from the upper part of the cylinder to the cylinder head via the heat transfer allowing portion by changing the flow condition of the cooling medium flowing in the cooling medium pathway when the combustion engine operation condition is at least low rotation frequency and high load of a condition of low rotation frequency and high load condition and a condition of high rotation frequency.

quency and high load condition.

[0011] And, the present invention is preferable if the heat transfer allowing portion is provided so as to surround a part of the gasket facing with the cylinder head and positioned on the side of a combustion chamber of the engine with an L-shape cross section.

[0012] And, the present invention is preferable if the heat transfer allowing portion and the gasket are structured with different members.

[0013] And, the present invention is preferable if a convex-concave portion capable of generating flow peeling of cooling medium according to flow speed within a range of maximum flow speed of the cooling medium is provided on a wall surface of a pathway on the side of the cylinder block in the cooling medium pathway.

[0014] And, the present invention is preferable if the cooling device further includes a cooling capacity adjusting portion that is capable of restraining cooling capacity of the cylinder head without restraining cooling capacity of the cylinder block, wherein the control portion performs a control for restraining the cooling capacity of the cylinder head by controlling the cooling capacity adjusting portion.

EFFECTS OF THE INVENTION

[0015] According to the present invention, it is possible to restrain occurrence of knocking by locally changing heat transfer condition of an engine with a reasonable condition and further preferably achieve reduction of cooling loss and knocking performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 illustrates a schematic view of a cooling device for an engine (hereinafter simply referred to as a cooling device) 1A.

FIG. 2 illustrates a schematic cross sectional view of one cylinder of an engine 50A.

FIG. 3 illustrates a schematic view of an ECU 70A.

FIG. 4 illustrates a schematic view of classes of combustion engine operation condition.

FIG. 5 illustrates a schematic view of heat transfer from an upper part of a cylinder 51 a to a cylinder head 52A via a high thermal conductivity member 54a with use of an arrow F1.

FIG. 6 illustrates a schematic view of heat transfer from the cylinder head 52A to the upper part of the cylinder 51 a via the high thermal conductivity member 54a.

FIG. 7 illustrates a flow chart of an operation of the ECU 70A.

FIG. 8 illustrates heat transfer rate and a rate of surface area of a combustion chamber 55 according to a crank angle.

FIG. 9 illustrates thermal efficiency of the cooling device 1A according to load. FIG. 9 illustrates a case

of a cooling device 1X that is substantially the same as the cooling device 1A except for not having a flow regulating valve 14, for comparison.

FIG. 10 illustrates a schematic view of a cooling device 1B.

FIG. 11 illustrates a schematic cross sectional view of one cylinder of an engine 50B;

FIG. 12 illustrates a flow chart of an operation of an ECU 70B.

FIG. 13 illustrates a case of full load and a partial load of a normal heat balance of a spark-ignition combustion engine.

FIG. 14 illustrates a normal case and high-thermal insulating case of an inner wall temperature and thermopenetration rate of a cylinder. FIG. 14 also illustrates a case where wall thickness of the cylinder is increased and material of the cylinder is changed and a case where thermal insulation with air having higher thermal insulation property is performed, as an example of increasing of thermal insulation property. As a normal structure, a normal engine having a single cooling water circulation pathway for flowing the cooling water from the lower part of the cylinder block to the cylinder head against gravitational force is illustrated.

MODES FOR CARRYING OUT THE INVENTION

[0017] Embodiments for carrying out the present invention are now described with reference to the drawings.

EMBODIMENT 1

[0018] A cooling device 1A illustrated in FIG. 1 is mounted on a car not illustrated, and has a water pump (hereinafter referred to as W/P) 11, a radiator 12, a thermostat 13, a flow regulating valve 14, an engine 50A, and an additional flow regulating valve 60. The W/P 11 is a cooling medium pumping portion and acts as a variable W/P pumping cooling water acting as a cooling medium and controlling flow amount of the pumped cooling water. The cooling water pumped by the W/P 11 is supplied to the engine 50A.

[0019] The engine 50A has a cylinder block 51 and a cylinder head 52A. The cylinder block 51 has a block-side water jacket (hereinafter referred to as a block-side W/J) acting as a first cooling medium pathway. A block-side W/J 511 forms one cooling system in the cylinder block 51. On the other hand, the cylinder head 52A has a head-side water jacket (hereinafter referred to as a head-side W/J) 521A acting as a second cooling medium pathway. The head-side W/J 521A forms a plurality of (in this case, five) different cooling systems in the cylinder head 52A. The cooling water pumped by the W/P 11 is supplied to the block-side W/J 511 and the head-side W/J 521A, in concrete.

[0020] In this point, the cooling device 1A has a plurality

of cooling water circulation pathways.

As the cooling water circulation pathway, there is formed a block-side circulation pathway C 1 that is a circulation pathway including the block-side W/J 511 or the like. The cooling water flowing in the block-side circulation pathway C1 is output from the W/P 11, flows in the block-side W/J 511, and returns to the W/P 11 via the thermostat 13 or via the radiator 12 and the thermostat 13. The radiator 12 is a heat exchanger and cools the cooling water by exchanging heat between the flowing cooling water and air. The thermostat 13 switches a flow pathway coupled to an inlet side of the W/P 11. In concrete, the thermostat 13 makes a flow pathway bypassing the radiator 12 communicating when temperature of the cooling water is less than a predetermined value, and makes a flow pathway passing through the radiator 12 communicating when the temperature of the cooling water is the predetermined value or more.

[0021] As another cooling water circulation pathway, there is provided a head-side circulation pathway C2 that is a circulation pathway including the head-side W/J 521A or the like. The cooling water flowing in the head-side circulation pathway C2 is output from the W/P 11, flows in the head-side W/J 521A via the flow regulating valve 14 or via the additional flow regulating valve 60, and returns to the W/P 11 via the thermostat 13 or via the radiator 12 and the thermostat 13.

[0022] The flow regulating valve 14 and the additional flow regulating valve 60 are provided downward compared to a branching point of the circulation pathway C1 and the circulation pathway C2 and upward compared to the cylinder head 52A. In this point, further specifically, the flow regulating valve 14 is provided according to the four cooling systems provided for cooling the cylinder head 52A of the five cooling systems formed by the head-side W/J 521A. The additional flow regulating valve 60 is provided according to one cooling system provided for changing the heat transfer condition in the engine 50A of the five cooling systems. The flow regulating valve 14 and the additional flow regulating valve 60 are provided in parallel.

[0023] The flow regulating valve 14 is a cooling-capacity-adjusting portion that is capable of adjusting cooling capacity of the cylinder head 52A. In this point, in concrete, the flow regulating valve 14 is a cooling-capacity-adjusting portion that is capable of adjusting the cooling capacity of the cylinder head 52A in whole by adjusting the flow amount of the cooling water flowing in the head-side W/J 521A (further specifically, four cooling systems provided in order to cool the cylinder head 52A) in whole. The flow regulating valve 14 with the structure is a cooling-capacity-adjusting portion that is capable of restraining the cooling capacity of the cylinder head 52A without restraining the cooling capacity of the cylinder

block 51 with respect to the cooling capacities, when the cylinder block 51 and the cylinder head 52A have the cooling capacity in the condition of high rotation frequency and high load where the cooling water flows in the cylinder block 51 and the cylinder head 52A

Further, the flow regulating valve 14 provided in this way is a cooling-capacity-adjusting portion that is capable of adjusting the flow amount of the cooling water flowing in the block-side W/J 511 so that the cooling capacity of the cylinder block 51 is enhanced, when the flow amount of the cooling water flowing in the head-side W/J 521A is adjusted so that the cooling capacity of the cylinder head 52A is restrained.

[0024] In the cooling device 1A, the cooling water flowing in the block-side circulation pathway C1 does not flow in the head-side W/J 521A until taking a round after pumped by the W/P 11. And, in the cooling device 1A, the cooling water flowing in the head-side circulation pathway C2 does not flow in the block-side W/J 511 until taking a round after pumped by the W/P 11. That is, in the cooling device 1A, the block-side W/J 511 and the head-side W/J 521A are built in cooling medium circulation pathways different from each other.

[0025] Next, a description will be given of the engine 50A further specifically. As illustrated in FIG. 2, the cylinder 51 a is provided in the cylinder block 51. A piston 53 is provided in the cylinder 51a. The cylinder head 52A is fixed to the cylinder block 51 through the gasket 54. The cylinder 51 a, the cylinder head 52A and the piston 53 form a combustion chamber 55. An intake port 52a for introducing intake air to the combustion chamber 55 and an exhaust port 52b for exhausting combustion gas from the combustion chamber 55 are provided in the cylinder head 52A. A spark plug 56 is provided at a substantially center of an upper part of the combustion chamber 55 in the cylinder head 52A.

[0026] The gasket 54 has thermal insulating property and acts as a thermal insulating member that is capable of restraining heat transfer between the cylinder block 51 and the cylinder head 52A with use of the high thermal insulating property. The gasket 54 has a high thermal conductivity member 54a having thermal conductivity higher than other portions of the gasket 54. For example, copper may be used as the high thermal conductivity member 54a. The high thermal conductivity member 54a is provided in an upper part of the cylinder 51 a. The high thermal conductivity member 54a faces with the cylinder head 52A in the gasket 54, surrounds a portion positioned on the side of the combustion chamber 55 in the engine 50A and has an L-shaped cross section.

In this point, the portion surrounded by the high thermal conductivity member 54a has high thermal insulating property. The high thermal conductivity member 54a provided in this way is exposed to the combustion chamber 55 and is in touch with a lower face of the cylinder head 52A. When the high thermal conductivity member 54a is provided, the heat transfer is performed preferably between the cylinder block 51 and the cylinder head 52A.

[0027] The high thermal conductivity member 54a, the portion surrounded by the high thermal conductivity member 54a, and the other portions form the gasket 54 integrally. The structure is not limited. The high thermal conductivity member 54a may be provided as another member of the gasket 54. In this point, the high thermal conductivity member 54a may be another member that allows heat transfer penetrating the gasket 54 between the upper part of the cylinder 51a and the cylinder head 52A (for example, a plurality of pin-shaped members). In the structure, heat can be transferred between the cylinder block 51 and the cylinder head 52A. The high thermal conductivity member 54a is a heat transfer allowing portion that allows heat transfer between the upper part of the cylinder 51a and the cylinder head 52A.

[0028] The block-side W/J 511 has a partial W/J 511a acting as a first partial cooling-medium pathway, in concrete. The partial W/J 511a is a cooling medium pathway provided around the cylinder 51a, in concrete. An upstream part of the partial W/J 511a can be provided according to a part of a wall of the cylinder 51a into which an intake air flowing into the cylinder runs, in view of cooling intake air preferably. In this point, the engine 50A is an engine for generating a positive tumble flow in the cylinder. The part into which the intake air flowing into the cylinder runs is an upper part of the wall of the cylinder 51a and a part on the side of exhaust.

[0029] In concrete, the head-side W/J 521A has a partial W/J 521a, a partial W/J 521b, a partial W/J 521c, a partial W/J 521d, and a partial W/J 521eA acting as the second partial cooling-medium pathway. The partial W/J 521a is a cooling medium pathway provided around the intake port 52a. The partial W/J 521b is a cooling medium pathway provided around the exhaust port 52b. The partial W/J 521c is a cooling medium pathway provided around the spark plug 56. The partial W/J 521d is a cooling medium pathway for cooling a part between the intake port 52a and the exhaust port 52b and the other parts. The partial W/J 521eA is a cooling medium pathway provided around the high thermal conductivity member 54a. The partial W/Js 521a through 521eA are built in five cooling systems formed by the head-side W/J 521A respectively. And, the flow regulating valve 14 is provided according to the partial W/Js 521a through 521d, in concrete. The additional flow regulating valve 60 is provided according to the partial W/J 521eA, in concrete.

[0030] Further, the cooling device 1A has an ECU (Electron Control Unit) 70A illustrated in FIG. 3. The ECU 70A has a micro computer including a CPU 71, a ROM 72, a RAM 73 and so on and an input/output circuits 75 and 76. These structures are coupled to each other via a bus 74. Sensor switches such as a crank angle sensor 81 for detecting rotation frequency of the engine 50A, an air flow meter 82 for measuring intake-air amount, an accelerator-open-angle sensor 83 for detecting an accelerator-open-angle, and a water temperature sensor 84 for detecting a temperature of cooling water are electrically coupled to the ECU 70A. In this point, the ECU 70A

detects the load of the engine 50A based on the outputs of the air flow meter 82, the accelerator open angle sensor 83 and so on. Control objectives such as the W/P 11, the flow regulating valve 14 and the additional flow regulating valve 60 and so on are electrically coupled to the ECU 70A.

[0031] The ROM 72 has a structure storing a program in which variable processing executed by the CPU 71 is described, a map data and so on. A control portion, a determination portion, a detection portion, a calculation portion and so on are functionally established in the ECU 70A when the CPU 71 uses a temporal storage area such as the RAM 73 as necessary and executes the processing based on the program stored in the ROM 72.

[0032] In this point, the control portion performing a control for restraining the cooling capacity of the cylinder head 52A is functionally realized in the ECU 70A.

In concrete, the control portion is realized so as to perform a control for restraining the cooling capacity of the cylinder head 52A when the combustion engine operation condition is high load.

Further specifically, the control portion is realized so as to perform a control for restraining the cooling capacity obtained according to the head-side W/J 521A by controlling the flow regulating valve 14 when the combustion engine operation condition is low rotation frequency and high load.

[0033] The control portion is realized so as to perform a control for making the heat transfer condition in the engine 50A partially changeable according to the combustion engine operation condition.

In concrete, the control portion is realized so as to perform a control for making the heat transfer condition between the upper part of the cylinder 51a and the cylinder head 52A via the high thermal conductivity member 54a changeable according to the combustion engine operation condition.

In this point, in concrete, the control portion is realized so as to perform a control for promoting the heat transfer from the upper part of the cylinder 51a to the cylinder head 52A via the high thermal conductivity member 54a when the combustion engine operation condition is high load (in concrete, low rotation frequency and high load, or high rotation frequency and high load).

The control portion is realized so as to perform a control for changing the flow condition of the cooling water flowing into the partial W/J 521eA by controlling the W/P 11 and the additional flow regulating valve 60, when the control portion performs a control for making the heat transfer condition between the upper part of the cylinder 51a and the cylinder head 52A via the high thermal conductivity member 54a according to the combustion engine operation condition.

In this point, the control portion is realized so as to perform a control for increasing the flow amount of the cooling water flowing into the partial W/J 521eA when the combustion engine operation condition is high rotation frequency and high load, compared to a case where the

combustion engine operation condition is low rotation frequency and high load.

[0034] The control portion is realized so as to perform a control for achieving the operation of the engine 50A in not only a case where the combustion engine operation condition is high load, but also another combustion engine operation condition.

In this point, in concrete, the combustion engine operation conditions are classified into six sections D1 to D6 illustrated in FIG. 4 according not only conditions of rotation frequency and load of the engine 50A, but also during cold operation or not or combustion starting or not. When the control portion performs the controls, the control portion sets requirements to be satisfied in the sections D1 to D6 and sets control indexes for satisfying the requirements.

[0035] When the combustion engine operation condition is an idling condition corresponding to the section D1, two requirements of improving of combustion speed caused by increase of intake-air temperature and increasing of exhaust air temperature for catalytic activity are set. In addition, according to the requirements, two control indexes of increasing of temperature of the intake port 52a and the upper part of the cylinder 51a and increasing of temperature of the exhaust port 52b are determined.

In this point, when increasing the temperature of the intake port 52a, for example, the flow regulating valve 14 may be closed or opened with a small open angle.

And, when increasing the temperature of the upper part of the cylinder 51a, for example, the W/P 11 may be stopped or driven with small exhaust amount, or the additional flow regulating valve 60 may be closed.

And, when increasing the temperature of the exhaust port 52b, the flow regulating valve 14 may be closed or opened with a small open angle.

[0036] When the combustion engine operation condition is low load corresponding to the section D2, two requirements of improving of thermal efficiency (reduction of cooling loss) and improving of combustion speed caused by increase of intake-air temperature are set. In addition, according to the requirements, two control indexes of thermally insulating of the cylinder head 52A and increasing of temperature of the intake port 52a and the upper part of the cylinder 51a are determined.

In this point, when thermally insulating the cylinder head 52A, for example, the flow regulating valve 14 may be closed or opened with a small open angle.

And, when increasing the temperature of the intake port 52a, for example, the flow regulating valve 14 can be closed or opened with a small open angle.

And, when increasing the temperature of the upper part of the cylinder 51a, for example, the W/P 11 may be stopped or driven with low discharge amount and the additional flow regulating valve 60 may be closed.

[0037] When the combustion engine operation condition is low rotation frequency and high load corresponding to the section D3, a requirement of reducing of knock-

ing and improving of thermal efficiency (reduction of cooling loss) is set. In addition, according to the requirement, a control index of cooling of the intake port 52a and the upper part of the cylinder 51a and thermally insulating of the cylinder head 52A is determined.

In this point, when cooling the intake port 52a, the flow regulating valve 14 may be fully opened or opened with a large open angle.

And, when cooling the upper part of the cylinder 51a, for example, the W/P 11 may be driven with a maximum discharge amount or large discharge amount applied to the combustion operating. Further, when cooling the upper part of the cylinder 51 a, for example, the additional flow regulating valve 60 may be opened.

And, when thermally insulating the cylinder head 52A, for example, the flow regulating valve 14 may be closed or opened with a small open angle.

[0038] When the combustion engine operation condition is high rotation frequency and high load corresponding to the section D4, two requirements of securing of reliability and reducing of knocking are set. In addition, according to the requirements, a control index of cooling of the circumference of the spark plug 56, a part between the intake port 52a and the exhaust port 52b, and the exhaust port 52b and a control index of cooling of the intake port 52a are determined.

In this point, when cooling the circumference of the spark plug 56, the part between the intake port 52a and the exhaust port 52b and the exhaust port 52b, the flow regulating valve 14 may be fully opened.

And, when cooling the intake port 52a, the flow regulating valve 14 may be opened fully.

On the other hand, with respect to the requirement of reducing the knocking, the upper part of the cylinder 51a may be cooled, in addition to cooling of the intake port 52a. On the other hand, when cooling the upper part of the cylinder 51 a, for example, the additional flow regulating valve 60 may be opened fully.

And, the W/P 11 may be driven with the maximum discharge amount applied to the combustion operating, for example.

[0039] During the cold combustion corresponding to the section D5, two requirements of promoting of combustion warming and improving of combustion speed by temperature increasing of intake-air are set. In addition, according to the requirements, two control indexes of promoting of heat transfer of the cylinder head 52A and increasing of temperature of the intake port 52a and the upper part of the cylinder 51a are determined.

In this point, when promoting the heat transfer of the cylinder head 52A, the flow regulating valve 14 may be opened in view of large contribution of heat-receiving of the cooling water in the cylinder head 52A.

And, when increasing the temperature of the intake port 52a, for example, the flow regulating valve 14 may be closed or opened with a small open angle.

And, when increasing the temperature of the upper part of the cylinder 51a, for example, the W/P 11 may be

stopped or driven with small discharge amount, or the additional flow regulating valve 60 may be closed.

[0040] During the combustion starting corresponding to the section D6, two requirements of improving of ignition performance and improving of fuel vaporization are set. In addition, according to the requirements, two control indexes of increasing of the temperature of the intake port 52a and increasing of the temperature of circumference of the spark plug 56 and the upper part of the cylinder 51a are determined.

In this point, when increasing the temperature of the intake port 52a, for example, the flow regulating valve 14 or the additional flow regulating valve 61 can be closed or opened with a small open angle.

And, when increasing the temperature of the circumference of the spark plug 56, for example, the flow regulating valve 14 or the additional flow regulating valve 63 may be closed or opened with a small open angle.

And, when increasing the temperature of the upper part of the cylinder 51a, for example, the W/P 11 may be stopped or driven with small discharge amount, or the additional flow regulating valve 60 may be closed or opened with a small open angle.

[0041] On the other hand, in the cooling device 1A, in view of matching property and simplification of whole control, the control portion is realized so as to perform a control for driving the W/P 11 so that the discharge amount gets larger basically according to the rotation frequency of the engine 50A as the rotation frequency gets higher. On the other hand, the flow regulating valve 14 and the additional flow regulating valve 60 are realized so as to perform controls as follows.

[0042] That is, the control portion is realized so as to perform a control for closing the flow regulating valve 14 and a control for closing the additional flow regulating valve 60 in a case where the combustion engine operation condition is idling condition corresponding to the section D1, in a case where the combustion engine operation condition is low load corresponding to the section D2, during the cold combustion corresponding to the section D5 and during the combustion starting corresponding to the section D6.

The control portion is realized so as to perform a control for opening the additional flow regulating valve 60 (here, half-opening in concrete) in addition to closing the flow regulating valve 14 or opening the flow regulating valve 14 in the condition of restraining the flow of the cooling water into the cylinder head 52A and restraining the vaporization of the cooling water in the cylinder head 52A (hereinafter referred to as a condition of restraining vaporization) when the combustion engine operation condition is low rotation and high load corresponding to the section D3.

And, the control portion is realized so as to perform a control for opening the additional flow regulating valve 60 (here, fully opening in concrete) in addition to performing a control for fully opening the flow regulating valve 14 when the combustion engine operation condition is

high rotation frequency and high load corresponding to the section D4.

[0043] In this point, In concrete, the control portion can open the flow regulating valve 14 with a minimum open angle restraining the vaporization of the cooling water in many conditions, can detect or estimate the temperature of the cooling water flowing in the cylinder head 52A and open the flow regulating valve 14 intermittently based on the temperature of the cooling water, and can open the flow regulating valve 14 at a predetermined rotation frequency or more, when performing the control for opening the flow regulating valve 14 with the condition of restraining vaporization in a case where the combustion engine operation condition is low rotation frequency and high load corresponding to the section D3. It is therefore possible to restrain that the flow regulating valve 14 is opened beyond necessity, in addition to restraining the vaporization of the cooling water, when restraining the cooling capacity of the cylinder head 52A.

[0044] And, the cooling device 1A partially reduces the flow amount of the cooling water flowing in the engine 50A when the flow regulating valve 14 reduces the flow amount of the cooling water flowing in the cylinder head 52A in the section D3 in this way under the control of the control portion.

And, the cooling device 1A restrains the cooling capacity of the cylinder head 52A by restraining the flow of the cooling water into the cylinder head 52A when the flow regulating valve 14 is not fully opened. In this point, the cooling device 1A restrains the cooling capacity of the cylinder head 52A when the flow regulating valve 14 is closed or the flow regulating valve 14 is opened with the condition of restraining vaporization.

[0045] And, the cooling device 1A changes the heat transfer between the upper part of the cylinder 51a and the cylinder head 52A when the W/P 11 and the additional flow regulating valve 60 change the flow amount of the cooling water flowing in the partial W/J 521 eA in this way under the control of the control portion, and thereby locally changes the condition of heat transfer of the engine 50A.

In this point, in the cooling device 1A, the W/P 11 and the additional flow regulating valve 60 that are capable of adjusting the flow amount of the cooling water flowing in the partial W/J 521 eA act as the heat transfer condition changing portion that locally changes the condition of the heat transfer of the engine 50A, by changing the condition of the heat transfer between the upper part of the cylinder 51a and the cylinder head 52A.

[0046] And, the cooling device 1A reduces the temperature of the circumference of the partial W/J 521 eA compared to the temperature of the upper part of the cylinder 51a when the control portion is performing the control for opening the additional flow regulating valve 60 in the sections D3 and D4 (that is, the control for allowing the flow of the cooling water of the partial W/J 521 eA so that heat is transferred from the upper part of the cylinder 51a to the cylinder head 52A via the high thermal conductivity

member 54a). And in this case, as illustrated with an arrow F1 in FIG. 5, the heat transfer from the upper part of the cylinder 51a to the cylinder head 52A via the high thermal conductivity member 54a is promoted.

[0047] On the other hand, in the cooling device 1A, heat is transferred between the circumference of the partial W/J 521 eA and the upper part of the cylinder 51a according to the temperature difference between them, when the control portion is performing the control for closing the additional flow regulating valve 60 in the sections D1, D2, D5 and D6 (that is, in a case where the control for stopping the flow of the cooling water of the partial W/J 521eA is performed). In this point, in this case, for example, during the cold combustion, when the cylinder head 52A receives much heat because of closing of the flow regulating valve 14 and thereby the temperature of the circumference of the partial W/J 521 eA gets higher than that of the upper part of the cylinder 51a, the heat transfer from the cylinder head 52A to the upper part of the cylinder 51a via the high thermal conductivity member 54a on the side of the exhaust as illustrated with an arrow F2 of FIG. 6 is promoted.

[0048] And in this case, thermal equilibration is obtained between the circumference of the partial W/J 521eA and the cylinder 51 a when the control portion controls the additional flow regulating valve 60 so that the temperature of the circumference of the partial W/J 521 eA is equal to the temperature of the upper part of the cylinder 51a by opening the additional flow regulating valve 60 with a small open angle or opening and closing the additional flow regulating valve 60 intermittently, and thereby the heat is not transferred between them or the heat transfer between them is restrained. On the other hand, for example, heat insulating function may be generated between the partial W/J 521 eA and the cylinder 51a when preventing the heat transfer between the partial W/J 521eA and the cylinder 51 a or restraining the heat transfer between them. In this case, for example, the temperature of the upper part of the cylinder 51a may be increased by not promoting the heat transfer from the upper part of the cylinder 51a to the cylinder head 52A via the high thermal conductivity member 54a.

[0049] In the cooling device 1A, the control portion is realized so as to perform a control in view of matching property and simplification of whole control. However, the control portion is not limited to this, but may be realized so as to perform a control that is different from the above-mentioned control in view of the matching property and the simplification of the whole control, by properly controlling the W/P 11, the flow regulating valve 14 and the additional flow regulating valve 60 based on the above-mentioned control indexes. It is therefore possible to achieve the operation of the engine 50A preferably.

[0050] Next, a description will be given of procedures executed by the ECU 70A, with reference to a flowchart illustrated in FIG. 7. The ECU 70A determines whether it is during the combustion starting or not (Step S1). In the case of affirmative determination, the ECU 70A starts

to drive the W/P 11 (Step S3). Next, the ECU 70A closes the flow regulating valve 14 and closes the additional flow regulating valve 60 (Step S21A). On the other hand, in the case of negative determination in the Step S1, the ECU 70A determines whether it is during the cold combustion or not (Step S5). It is possible to determine whether it is during the cold combustion or not, according to whether the temperature of the cooling water is equal to a predetermined value (for example, 75 degrees C) or less. In the case of affirmative determination in the Step S5, the ECU 70A executes the Step S21A. In the case of negative determination in the Step S5, the ECU 70A detects the rotation frequency and the load of the engine 50A (Step S11).

[0051] Next, the ECU 70A detects the section according to the detected rotation frequency and load (Steps S12 to S14). In concrete, the ECU 70A proceeds to the Step S21 from the affirmative determination of the Step S12 when the according section is the section D1, and proceeds to the Step S21 from the affirmative determination of the Step S13 when the according section is the section D2. On the other hand, the ECU 70A proceeds to the Step S31A from the affirmative determination of the Step S14 when the according section is the section D3. In this case, the ECU 70A opens the additional flow regulating valve 60 halfway, in addition to closing the flow regulating valve 14 or opening the flow regulating valve 14 in the condition of restraining vaporization (Step S31A). The ECU 70A proceeds to the Step S41A from the negative determination of the Step S14 when the according section is the section D4. In this case, the ECU 70A opens the flow regulating valve 14 fully and opens the additional flow regulating valve 60 fully (Step S41A).

[0052] Next, a description will be given of the function effect of the cooling device 1A. Here, the heat transfer rate and the surface area rate of the combustion chamber 55 according to the crank angle of the engine 50A are illustrated in FIG. 8. As illustrated in FIG. 8, it is found that the heat transfer rate increases to the top dead point or around of the compression stroke. With respect to the surface area rate, it is found that the surface area rate of the cylinder head 52A and the piston 53 gets larger at the top dead point or around of the compression stroke. Therefore, with respect to the cooling loss, it is found that the influence of the temperature of the cylinder head 52A is large. On the other hand, it is found that the surface area rate of the cylinder 51 a is large in the intake-air compression stroke having an influence on the temperature of the compression end, although the knocking depends on the temperature of the compression end. It is therefore found that the influence of the temperature of the cylinder 51a is large with respect to the knocking.

[0053] On the other hand, based on the knowledge, the cooling device 1A closes the flow regulating valve 14 or opens the flow regulating valve 14 in the condition of restraining vaporization, when the combustion engine operation condition is low rotation frequency and high load. Thus, it is possible to restrain the cooling capacity

of the cylinder head 52A and thereby reduce the cooling loss, by limiting the flow amount of the cooling water flowing in the head-side W/J 521A.

On the other hand, in this case, the occurrence of knocking is concerned. On the other hand, the cooling device 1A limits the flow amount of the cooling water flowing in the head-side W/J 521A by controlling the flow regulating valve 14 that is capable of restraining the cooling capacity of the cylinder head 52A without restraining the cooling capacity of the cylinder block 51. Therefore, the cooling device 1A can keep the cooling of the cylinder 51a and thereby restrain the occurrence of the knocking.

[0054] The cooling device 1A can thermally insulate the cylinder head 52A (reduction of cooling loss) by locally changing the condition of the heat transfer in a reasonable condition based on the above-mentioned knowledge and thereby can cool the cylinder block 51 and restrain the occurrence of the knocking. And, it is possible to improve the thermal efficient as illustrated in FIG. 9, by achieving the reduction of the cooling loss and the knocking performance.

[0055] And, the cooling device 1A can adjust the flow amount of the cooling water flowing in the block-side W/J 511 so that the cooling capacity of the cylinder block 51 is increased, when the flow regulating valve 14 adjusts the flow amount of the cooling water flowing in the head-side W/J 521A so that the cooling capacity of the cylinder head 52A is restrained. Thereby, the cooling device 1A can cool the intake air and restrain the occurrence of the knocking more preferably.

Further, the cooling device 1A can promote the heat transfer from the upper part of the cylinder 51a to the cylinder head 52A via the high thermal conductivity member 54a by opening the additional flow regulating valve 60 when the combustion engine operation condition is high load. Thus, the cooling device 1A can further promote the cooling of the upper part of the cylinder 51a and thereby can restrain the occurrence of knocking more preferably.

[0056] And, the cooling device 1A can improve the thermal efficiency mainly during the condition of low rotation frequency and high load. On the other hand, the cooling device 1A can achieve the operation of the engine 50A in another operation condition. In this point, the cooling device 1A can, for example, reduce the thermal load of the catalyst caused by temperature decrease of the exhaust air, in addition to securing reliability and reducing of the knocking during the condition of high rotation frequency and high load. And, during the condition of high rotation frequency and high load, for example, it is possible to improve, for example, the reliability by lowering the temperature between bores in addition to reducing of the knocking, by increasing the flow amount of the cooling water flowing in the partial W/J 52 1 eA more than during the condition of low rotation frequency and high load. And, for example, during the cold combustion for closing the additional flow regulating valve 60, it is possible to reduce the unburn loss and the friction loss al-

lowed by the temperature increase of the wall surface of the cylinder 51a, by promoting the heat transfer from the cylinder head 52A to the upper part of the cylinder 51a via the high thermal conductivity member 54a. Therefore, the cooling device 1A can improve the thermal efficient with respect to not only a specific operation condition but also whole operation of the engine 50A performed normally.

10 EMBODIMENT 2

[0057] As illustrated in FIG. 10, a cooling device 1B in accordance with a second embodiment is substantially the same as the cooling device 1A except for points that an engine 50B is provided instead of the engine 50A, the additional flow regulating valve 60 is not provided, and an ECU 70B is provided instead of the ECU 70A as described later. The cooling device 1B may have the additional flow regulating valve 60, as well as the cooling device 1A. The engine 50B is substantially the same as the engine 50A except for a point that a cylinder head 52B is provided instead of the cylinder head 52A. The cylinder head 52B is substantially the same as the cylinder head 52A except for a point that a head-side W/J 521B is provided instead of the head-side W/J 521A. The head-side W/J 521B is substantially the same as the head-side W/J 521A except for a point that a partial W/J 52 1 eB described later is provided instead of the partial W/J 521eA.

[0058] As illustrated in FIG. 11, the engine 50B has the partial W/J 521eB instead of the partial W/J 521eA. The partial W/J 521eB is substantially the same as the partial W/J 52 1 eA except for a point that a convex-concave portion P capable of generating flow peeling of the cooling water according to the flow speed changing. In concrete, the convex-concave portion P is provided on a face on the side of the high thermal conductivity member 54a, in the inner wall surface of the partial W/J 521eB. And, in concrete, the convex-concave portion P is formed by a porous shape.

[0059] In this point, in a case where, for example, the above-mentioned additional flow regulating valve 60 is provided as a flow speed changing portion for changing the flow speed of the cooling water flowing in the partial W/J 52 1 eB according to the combustion engine operation condition, a concrete shape of the convex-concave portion P is not specifically limited, if the concrete shape of the convex-concave portion P is a convex-concave capable of generating the flow peeling of the cooling water according to the changing of the flow speed or another convex-concave having surface roughness (that is, capable of not generating the flow peeling of the cooling water at a predetermined flow speed or less and generating the flow peeling of the cooling water at a flow speed higher than the predetermined flow speed in a range of the maximum flow speed of the cooling water that can be applied in the combustion operation).

[0060] On the other hand, in the cooling device 1B, the concrete shape of the convex-concave portion P is a con-

vex-concave or a shape having surface roughness that are capable of not generating the flow peeling of the cooling water according to the condition of the W/P 11 and the flow regulating valve 14 corresponding to the low rotation frequency when the combustion engine operation condition is low rotation frequency and generating the flow peeling of the cooling water according to the condition of the W/P 11 and the flow regulating valve 14 corresponding to the high rotation frequency when the combustion engine operation condition is high rotation frequency.

[0061] The ECU 70B is substantially the same as the ECU 70A except for points that the additional flow regulating valve 60 is not electrically coupled to the ECU 70B as a control objective and the control portion is realized as follows. Therefore, illustration of the ECU 70B is omitted.

With respect to the W/P 11, the ECU 70B realizes the control portion so as to drive the W/P 11 so that the discharge amount gets larger as the rotation frequency gets higher basically according to the rotation frequency of the engine 50B, in view of the matching property and the simplification of the whole control. On the other hand, with respect to the ECU 70B, the control portion is realized so as to control the flow regulating valve 14 as follows.

[0062] That is, the control portion is realized so as to close the flow regulating valve 14 in a case where the combustion engine operation condition is the idling condition corresponding to the section D1, in a case where the combustion engine operation condition is low load corresponding to the section D2, during the cold combustion corresponding to the section D5, and during the combustion starting corresponding to the section D6.

And, the control means is realized so as to open the flow regulating valve 14 with the condition of restraining vaporization, when the combustion engine operation condition is low rotation frequency and high load corresponding to the section D3. In this point, when the flow regulating valve 14 is opened with the condition of restraining vaporization, the flow regulating valve 14 is realized so as to open the flow regulating valve 14 with a minimum open angle allowing the restraint of the vaporization of the cooling water in variable conditions.

And, the control portion is realized so as to open the flow regulating valve 14 fully when the combustion engine operation condition is high rotation frequency and high load corresponding to the section D4.

When the additional flow regulating valve 60 is provided as well as the cooling device 1A, the control portion may be realized so as to open the additional flow regulating valve 60 with an open angle so that the flow peeling of the cooling water is not occurred in the partial W/J 52 1 eB in addition to closing the flow regulating valve 14 or opening the flow regulating valve 14 with the condition of restraining vaporization when the combustion engine operation condition is low rotation frequency and high load. This case is preferable in a point that the cooling

loss of the cylinder head 52B is more reduced.

[0063] Next, a description will be given of proceedings performed by the ECU 70B with reference to a flowchart illustrated in FIG. 12. The flowchart is the same as the flowchart illustrated in FIG. 7 except for points that Step S21B is executed instead of the Step S21A, Step S31B is executed instead of the Step S31A, and Step S41B is executed instead of the Step S41A. Therefore, a description will be given of the steps specifically. After execution of the Step S3 or in the case of affirmative determination in the Steps S5, S12 and S 13, the ECU 70B closes the flow regulating valve 14 (Step S21B). In the case of negative determination in the Step S14, the ECU 70B opens the flow regulating valve 14 with the condition of restraining vaporization (Step S31B). And, in the case of the negative determination in the Step S 14, the ECU 70B opens the flow regulating valve 14 fully (Step S41B).

[0064] Next, a description will be given of function effect of the cooling device 1B. With respect to the cooling device 1B, the discharge amount of the W/P 11 gets larger basically according to the rotation frequency of the engine 50B, as the rotation frequency of the engine 50B gets higher. And, the cooling device 1B opens the flow regulating valve 14 with the condition of restraining vaporization when the combustion engine operation condition is low rotation frequency. Therefore, with respect to the cooling device 1B, the flow amount of the cooling water flowing in the partial W/J 52 1 eB is reduced relatively when the combustion engine operation condition is low rotation frequency and high load. Thus, the flow speed of the cooling water flowing in the partial W/J 52 1 eB reaches a flow speed so that the flow peeling of the cooling water is not occurred at the convex-concave portion P.

[0065] Therefore, with respect to the cooling device 1B, the micro structure of the convex-concave portion P contributes to enlargement of the surface area contacting to the cooling water when the combustion engine operation condition is low rotation frequency and high load. Thereby, it is possible to promote the heat transfer from the upper part of the cylinder 51a to the cylinder head 52B via the high thermal conductivity member 54a. Therefore, the cooling device 1B can restrain the occurrence of knocking preferably during the condition of low rotation frequency and high load reducing the discharge amount of the W/P 11 relatively.

[0066] On the other hand, with respect to the cooling device 1B, the discharge amount of the W/P 11 gets larger relatively and the flow regulating valve 14 opens fully, when the combustion engine operation condition is high rotation frequency and high load. Therefore, with respect to the cooling device 1B, the flow amount of the cooling water flowing in the partial W/J 52 1 eB gets larger relatively when the combustion engine operation condition is high rotation frequency and high load. Thus, the flow speed of the cooling water flowing in the partial W/J 52 1 eB reaches a flow speed so that the flow peeling of the cooling water occurs at the convex-concave portion P.

[0067] Therefore, in the cooling device 1B, the heat transfer from the upper part of the cylinder 51a to the cylinder head 52B via the high thermal conductivity member 54a is restrained when the combustion engine operation condition is high rotation frequency and high load, because exchange of the cooling water in the micro structure of the convex-concave portion P is restrained and nuclear boiling occurs. That is, in the cooling device 1B, at least, the control portion performs a control for preventing the heat transfer between the partial W/J 521 eB and the cylinder 51a or a control for restraining the heat transfer between the partial W/J 521 eB and the cylinder 51a, because thermal insulation caused by the flow peeling of the cooling water occurs at the convex-concave portion P when the combustion engine operation condition is high rotation frequency and high load. However, in this case, the occurrence of knocking is restrained because the discharge amount of the W/P 11 is large and the cooling effect of the cooling water flowing in the partial W/J 511 a and the partial W/J 521b is obtained.

[0068] Therefore, the cooling device 1B is preferable in a point the occurrence of knocking is restrained with a proper balance between during the condition of low rotation frequency and high load lowering the discharge amount of the W/P 11 and during the condition of high rotation frequency and high load enlarging the discharge amount of the W/P 11, when the discharge amount of the W/P 11 is set so that the rotation frequency of the engine 50B gets higher basically according to the engine 50B, as the rotation frequency gets higher.

And, the additional flow regulating valve 60 may not be provided when restraining the occurrence of knocking, because the occurrence of knocking can be restrained in this way. That is, in the cooling device 1B, the changing of the discharge amount of the W/P 11 according to the rotation frequency of the engine 50B can control the flow of the cooling water at the convex-concave portion P adequately, even if the additional flow regulating valve 60 is not provided. It is therefore possible to simplify the structure of the cooling device 1B.

When the cooling device 1B has the additional flow regulating valve 60 as well as the cooling device 1A, the control portion may be realized so as to fully open the flow regulating valve 14 and open the additional flow regulating valve 60 with an angle preventing the flow peeling of the cooling water in the W/J 52 1 eB when the combustion engine operation condition is high rotation frequency and high load. In this case, the occurrence of knocking during the condition of high rotation frequency and high load can be restrained more preferably.

[0069] The above-mentioned embodiments are preferable examples of the present invention. The present invention is not limited to the embodiments and variations but may include other embodiments and variations without departing from the scope of the present invention. For example, in the above-mentioned embodiments, the case where the W/P 11 is the cooling medium pumping portion is described, because the W/P 11 is preferable

when achieving the operation of the engines 50A and 50B. However, the present invention is not limited to the structure. For example, the cooling medium pumping portion may be a mechanical W/P operating with the output of the engine.

[0070] In the above-mentioned embodiments, the control example in which the control portion performs controls based on the above-mentioned control indexes when achieving the operation of the engines 50A and 50B is described.

However, the present invention is not limited to the example. The control portion may perform another control properly when achieving the operation of the engine. In this point, for example, when the first cooling medium pathway provided in the cylinder block includes a plurality of first partial cooling medium pathways and the second cooling medium pathway provided in the cylinder head includes a plurality of second partial cooling medium pathways, a plurality of partial cooling capacity adjusting portions capable of partially adjusting the cooling capacity of the cylinder block or the cylinder head according to each of the first partial cooling medium pathways and the second partial cooling medium pathways may be provided, and the cooling medium pumping portion, the cooling capacity adjusting portion, the flow amount changing portion, and the partial cooling capacity adjusting portion may be controlled properly. Thus, the operation of the engine may be achieved more preferably.

[0071] In the above-mentioned embodiments, the case where the control portion performs the control for restraining the cooling capacity obtained by each of the head-side W/Js 521 as the cooling capacity of the cylinder heads 52A and 52B by performing the control for closing the flow regulating valve 14 or opening the flow regulating valve 14 with the condition of restraining vaporization when the combustion engine operation condition is low rotation frequency and high load corresponding to the section D3 is described.

However, the present invention is not limited to the structure. The cooling device may further include a pooling portion for pooling cooling medium extracted from the second cooling medium pathway and a cooling medium pumping portion for transferring the cooling medium between the pooling portion and the second cooling medium pathway. In addition, the control portion may perform a control for extracting the cooling medium from the cylinder head at least temporally by controlling the cooling medium pumping portion, when the combustion engine operation condition is low rotation frequency and high load. In concrete, there are a heat-accumulating tank and electric-powered pump described in Japanese Patent Application Publication No. 2009-79505, as the structure corresponding to the pooling portion and the cooling medium pumping portion. With the structure, it is possible to reduce the cooling loss more preferably.

[0072] The pooling portion, the cooling medium pumping portion and the control portion may be applied when the combustion engine operation condition is the condi-

tion of idling or low load or during the cold combustion. Further, in this case, as the pooling portion, a first pooling portion and a second pooling portion for pooling the cooling medium extracted from the first cooling medium pathway and the second cooling medium pathway may be provided. In addition, as the cooling medium pumping portion, a first cooling medium pumping portion transferring the cooling medium between the first pooling portion and the first cooling medium pathway and a second cooling medium pumping portion transferring the cooling medium between the second pooling portion and the second cooling medium pathway may be provided. In this case, when common cooling medium flows in the first cooling medium pathway and the second cooling medium pathway, the first pooling portion and the second pooling portion may act as a single pooling portion, and the first cooling medium pumping portion and the second cooling medium pumping portion may act as a single cooling medium pumping portion.

With the structure, the combustion speed is improved more, the cooling loss is reduced more, and combustion warming is promoted more. Thereby, the operation of the engine can be achieved more preferably.

[0073] In the above-mentioned first embodiment, the case where the control portion performs the control for closing the flow regulating valve 14 during the idling condition of the combustion engine operation condition, during the cold combustion, or during the combustion starting is described.

However, the present invention is not limited to the case. For example, the cooling device may include a heat-accumulating cooling medium supply portion that is capable of supplying heat-accumulating cooling medium in the first cooling medium pathway and the second cooling pathway. In addition, when the temperature of the heat-accumulating medium is higher than that of the cooling medium, the control portion may perform a control for supplying the heat-accumulating cooling medium from the heat-accumulating cooling medium supply portion during the idling condition of the combustion engine operation condition, during the cold combustion, or during the combustion starting. In concrete, for example, as a structure of the heat-accumulating medium supply portion, there is a heat exchanger described in Japanese Patent Application Publication No. 2009-208569.

Further, in this case, the control portion may perform a control for enlarging the flow amount of the heat-accumulating medium by controlling one or more partial cooling capacity adjusting portion provided according to the spark plug, the exhaust port and the intake port in the partial cooling capacity adjusting portions that partially adjust the cooling capacity of the cylinder head.

With the structure, it is possible to promote the combustion warming, reduce unburn HC, and improve ignition performance of the engine more preferably. As a result, the operation of the engine can be achieved more preferably.

[0074] And, it is reasonable that the control portion is

mainly realized by the ECU 70 controlling the engines 50A and 50B. However, for example, the control portion may be realized by hard wares such as other electronic control devices, other dedicated electronic circuits or a combination of them. And, the control portion allowing distributed control may be realized by hard wares such as a plurality of electronic control devices, a plurality of dedicated electronic circuits or a combination of them.

DESCRIPTION OF LETTERS OR NUMERALS

[0075]

1	Cooling device
11	W/P
12	Radiator
13	Thermostat
14	Flow regulating valve
50A, 50B, 50C	Engine
51 a	Cylinder
511	block-side W/J
52A, 52B	Cylinder head
52a	Intake port
52b	Exhaust port
521	Head-side W/J
54	Gasket
54a	High thermal conductivity member
60	Additional flow regulating valve
70	ECU

Claims

1. A cooling device for engine comprising:

an engine having a cylinder block, a cylinder head, and a gasket, the gasket being provided between the cylinder block and the cylinder head and having a heat transfer allowing portion allowing heat transfer between an upper part of a cylinder of the cylinder block and the cylinder head with a heat transfer rate higher than the other part, a cooling medium pathway being provided around the heat transfer allowing portion in the cylinder head; and
a control portion performing a control for changing flow condition of cooling medium flowing in the cooling medium pathway, according to combustion engine operation condition.

2. The cooling device for engine as claimed in claim 1, wherein the control portion performs a control for promoting heat transfer from the upper part of the cylinder to the cylinder head via the heat transfer allowing portion by changing the flow condition of the cooling medium flowing in the cooling medium pathway when the combustion engine operation condition is at least low rotation frequency and high load of a

condition of low rotation frequency and high load condition and a condition of high rotation frequency and high load condition.

3. The cooling device for engine as claimed in claim 1 or 2, wherein the heat transfer allowing portion is provided so as to surround a part of the gasket facing with the cylinder head and positioned on the side of a combustion chamber of the engine with an L-shape cross section. 5
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4. The cooling device for engine as claimed in any of claims 1 to 3, wherein the heat transfer allowing portion and the gasket are structured with different members. 15
5. The cooling device for engine as claimed in any of claims 1 to 4, wherein a convex-concave portion capable of generating flow peeling of cooling medium according to flow speed within a range of maximum flow speed of the cooling medium is provided on a wall surface of a pathway on the side of the cylinder block in the cooling medium pathway. 20
6. The cooling device for engine as claimed in any of claims 1 to 5, further comprising a cooling capacity adjusting portion that is capable of restraining cooling capacity of the cylinder head without restraining cooling capacity of the cylinder block, wherein the control portion performs a control for restraining the cooling capacity of the cylinder head by controlling the cooling capacity adjusting portion. 25
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FIG. 1

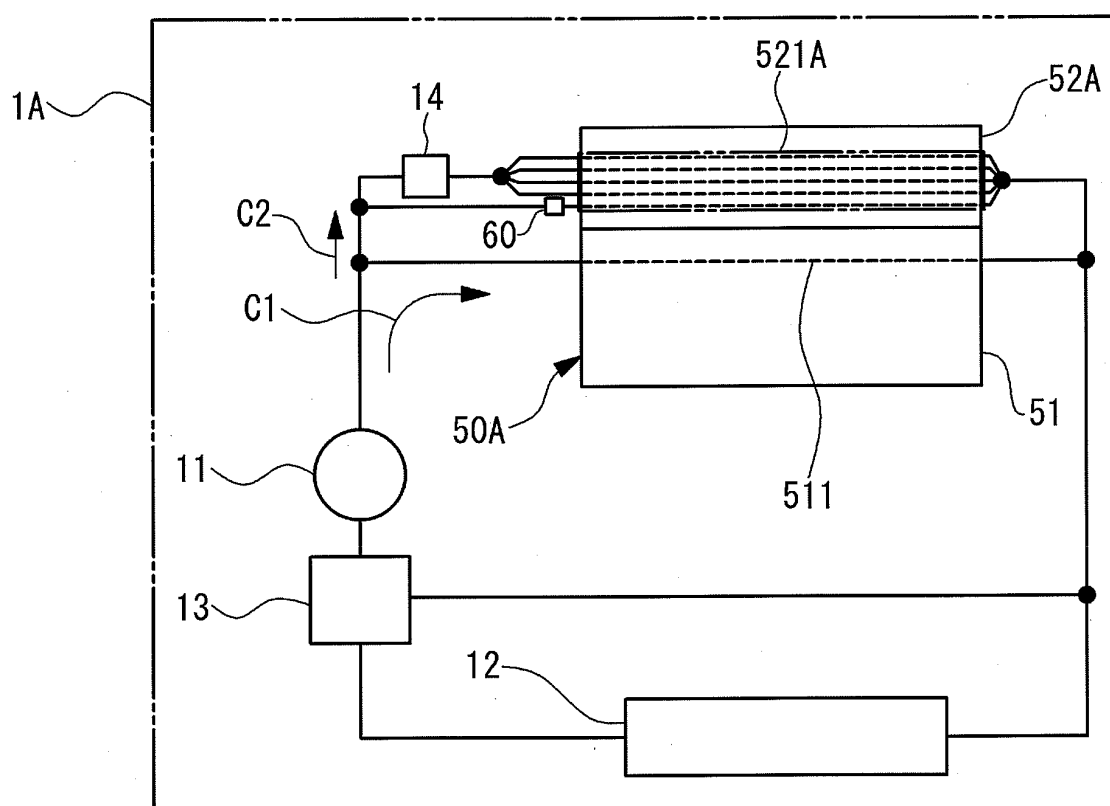


FIG. 2

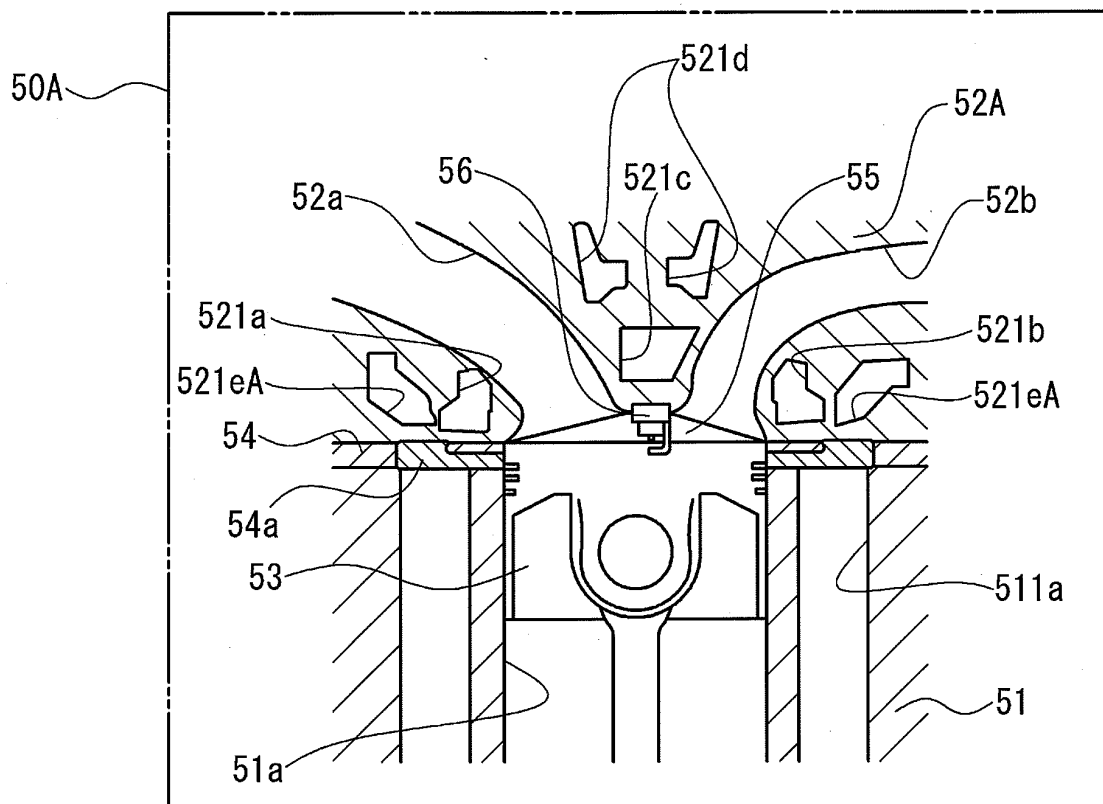


FIG. 3

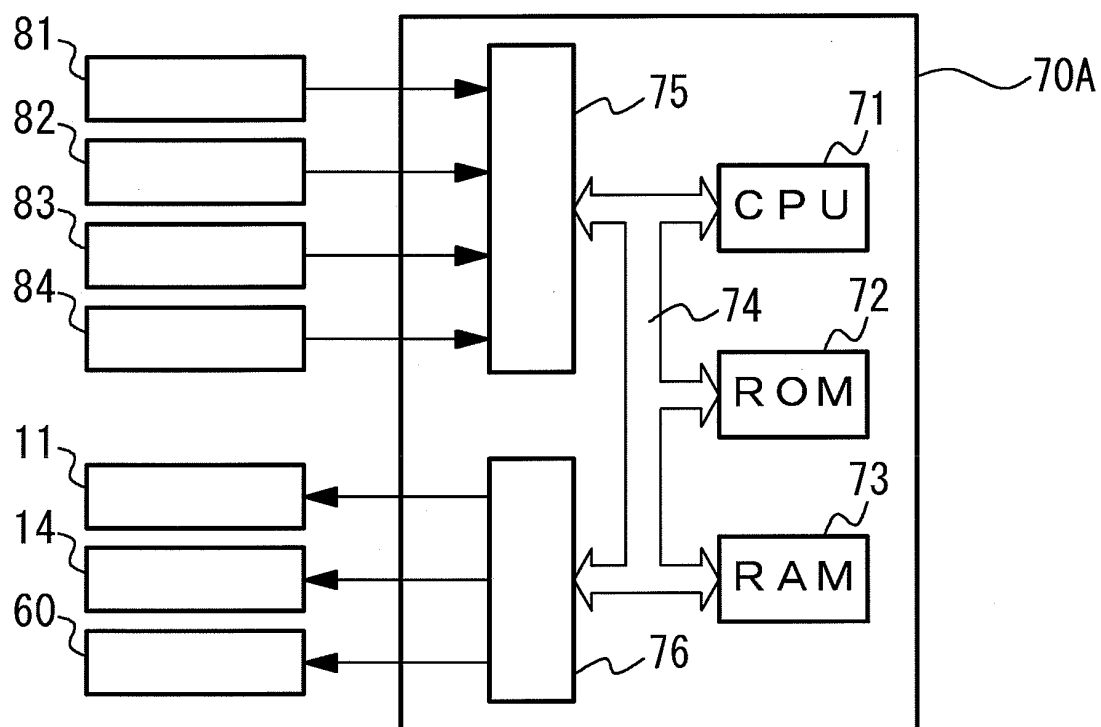


FIG. 4

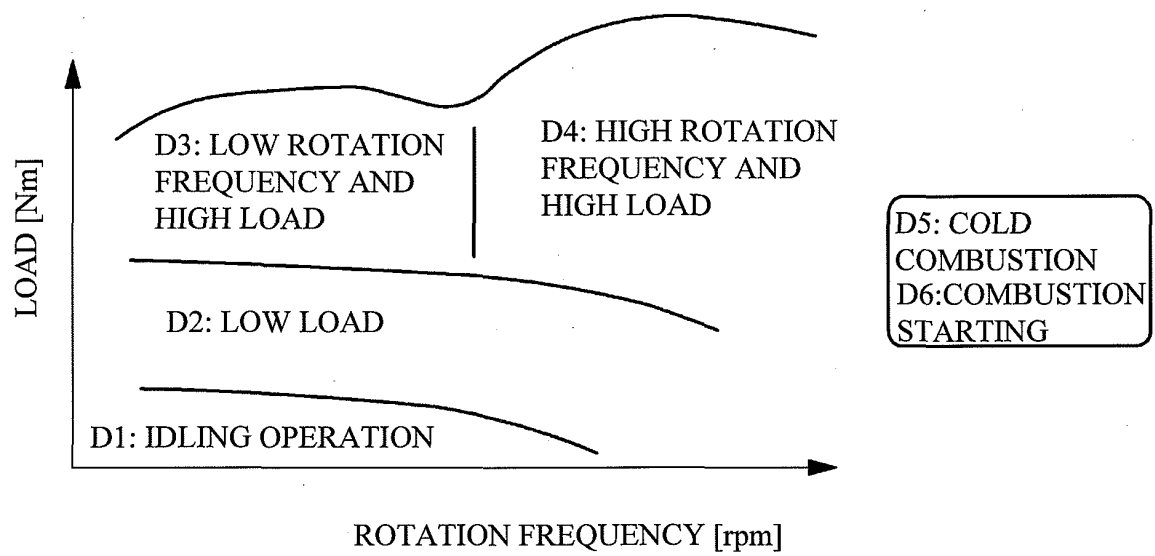


FIG. 5

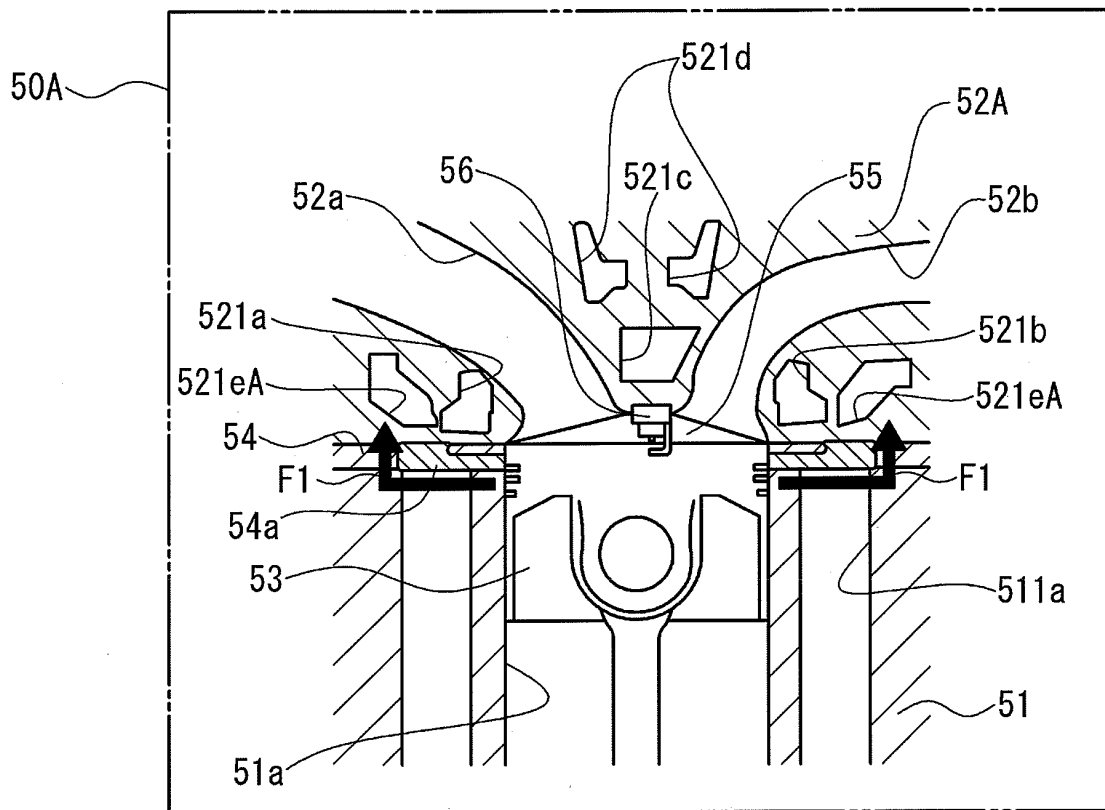


FIG. 6

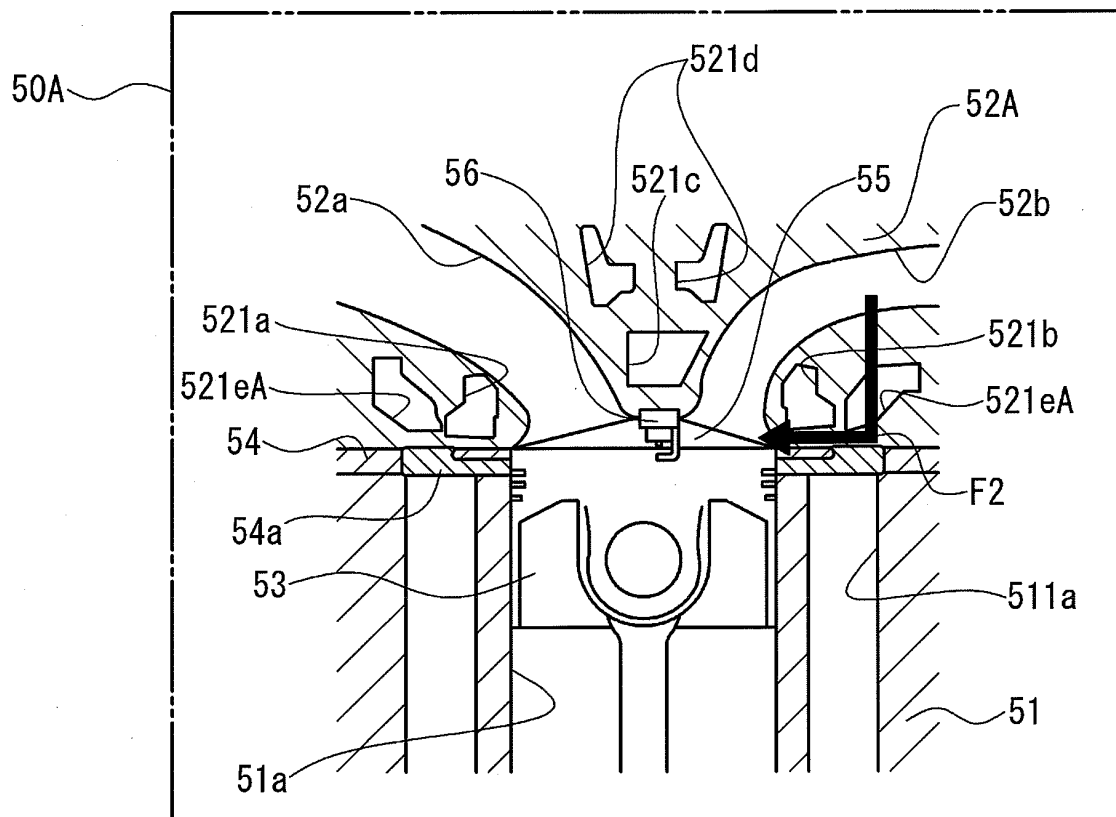


FIG. 7

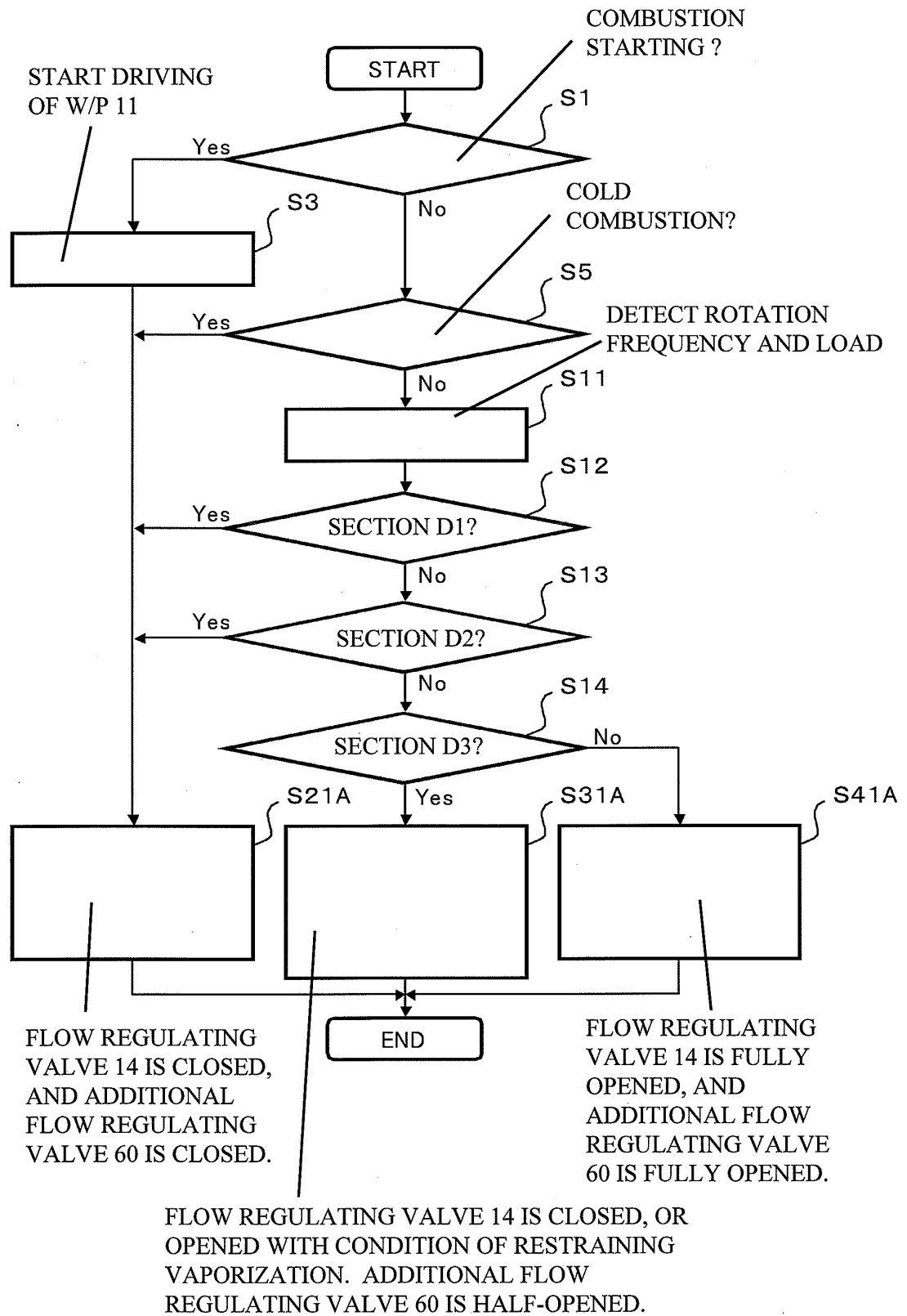


FIG. 8

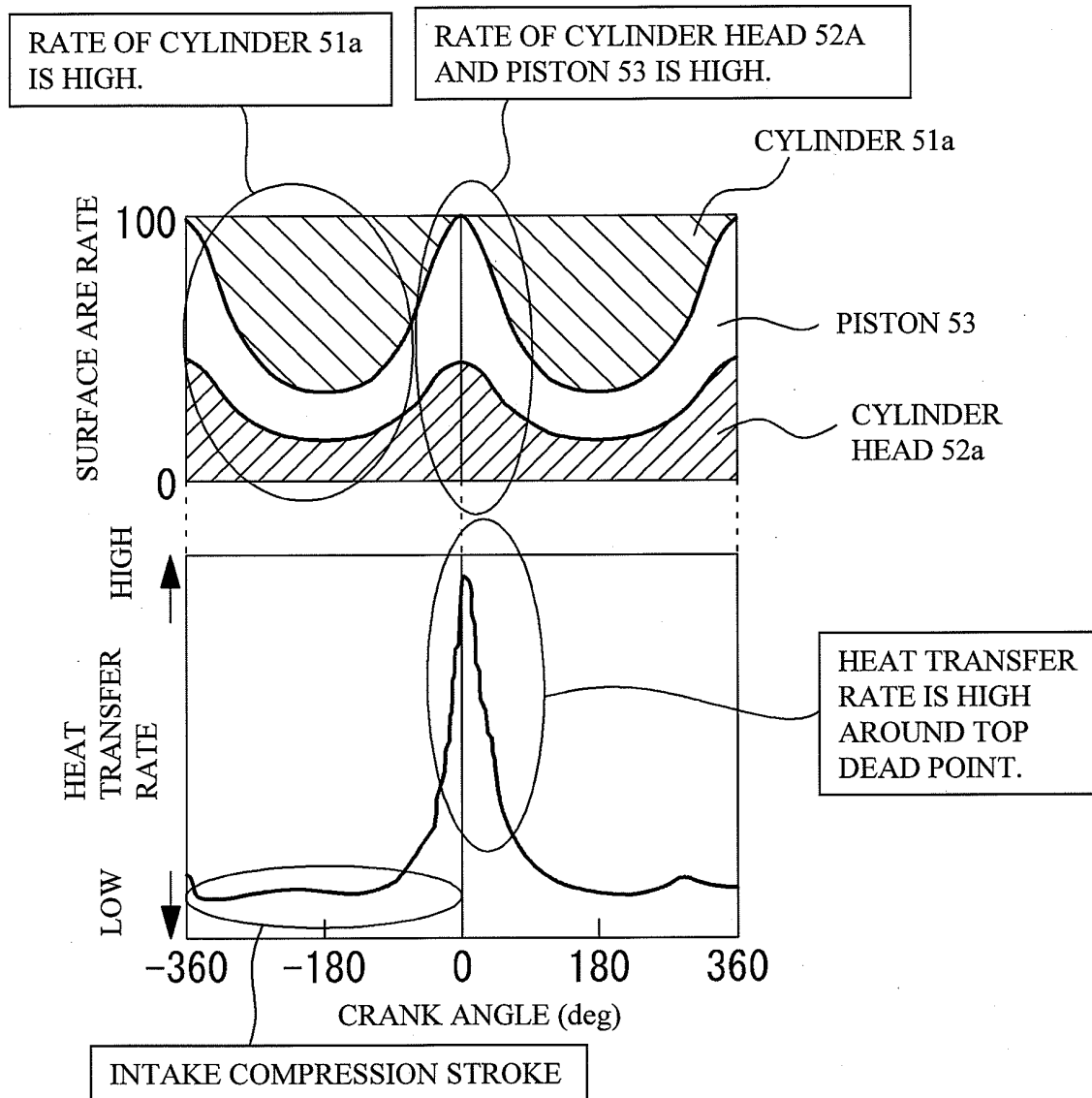


FIG. 9

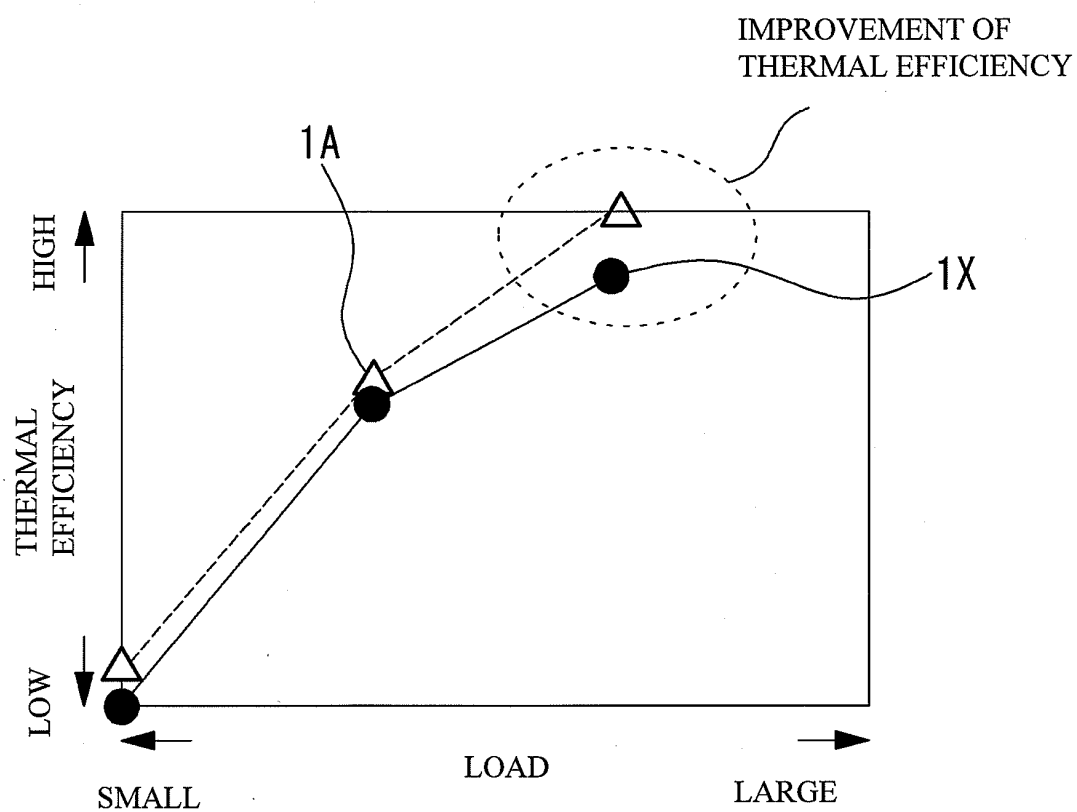


FIG. 10

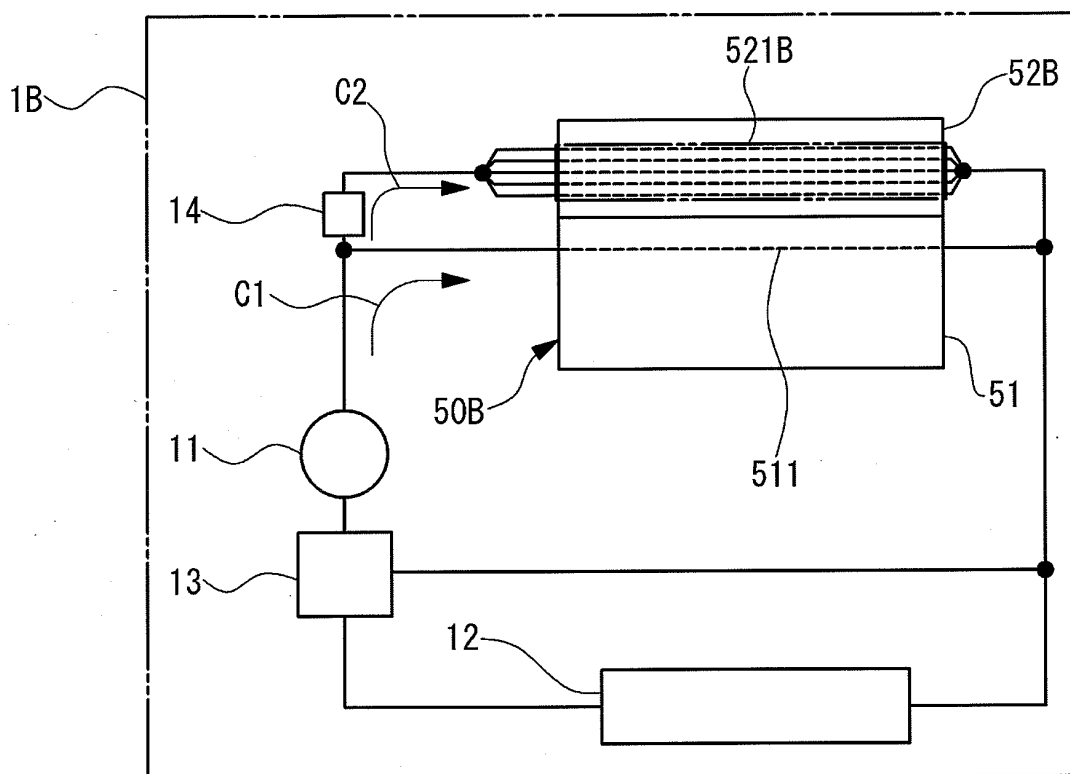


FIG. 11

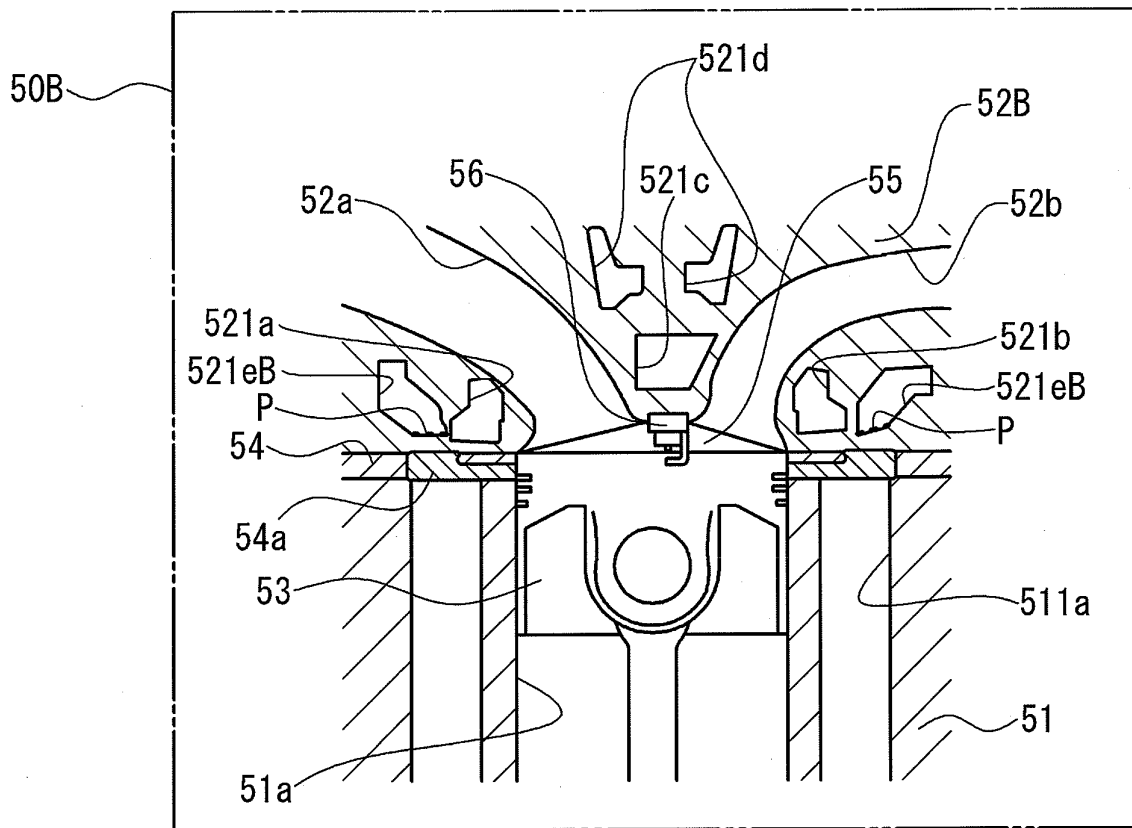


FIG. 12

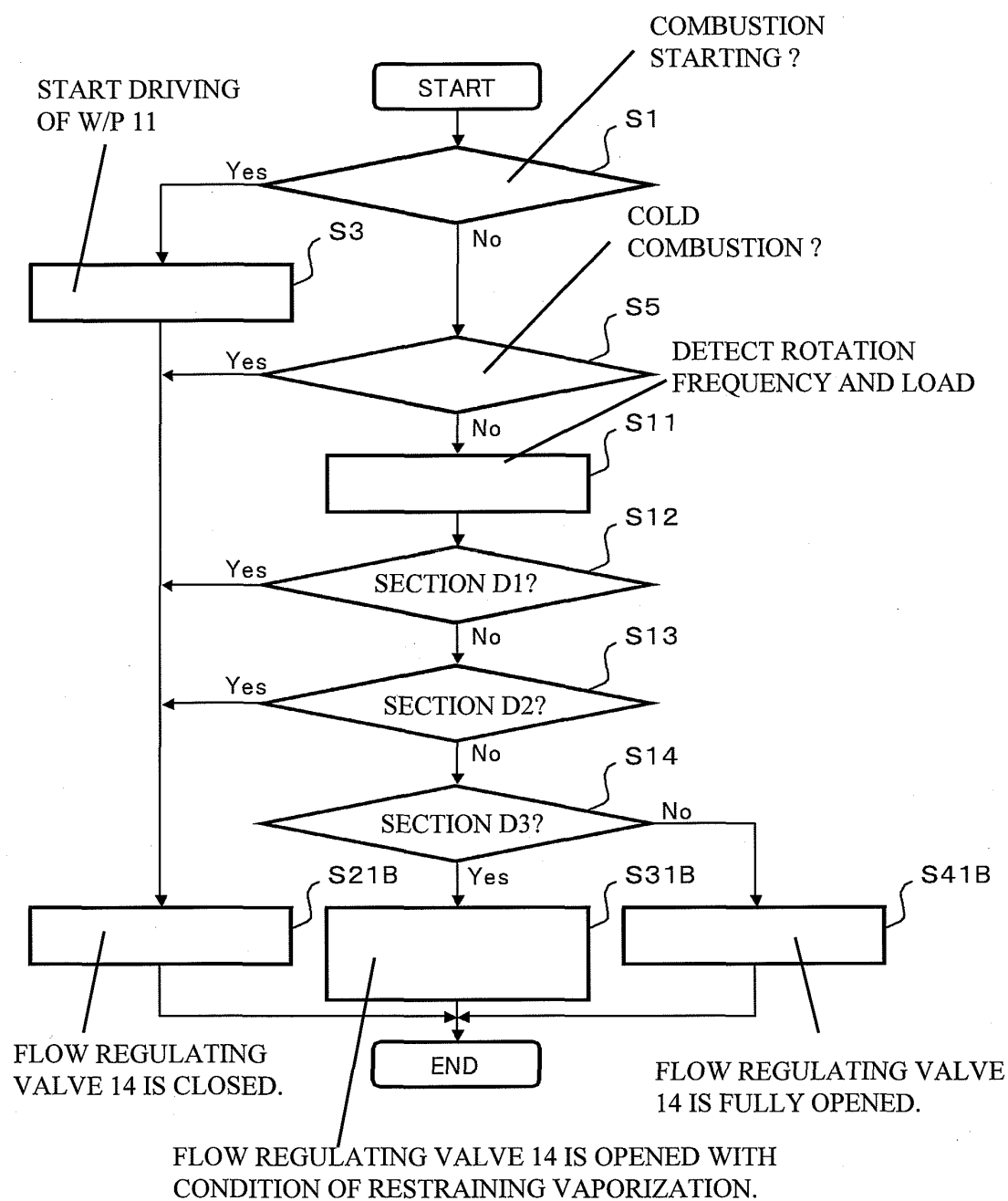


FIG. 13

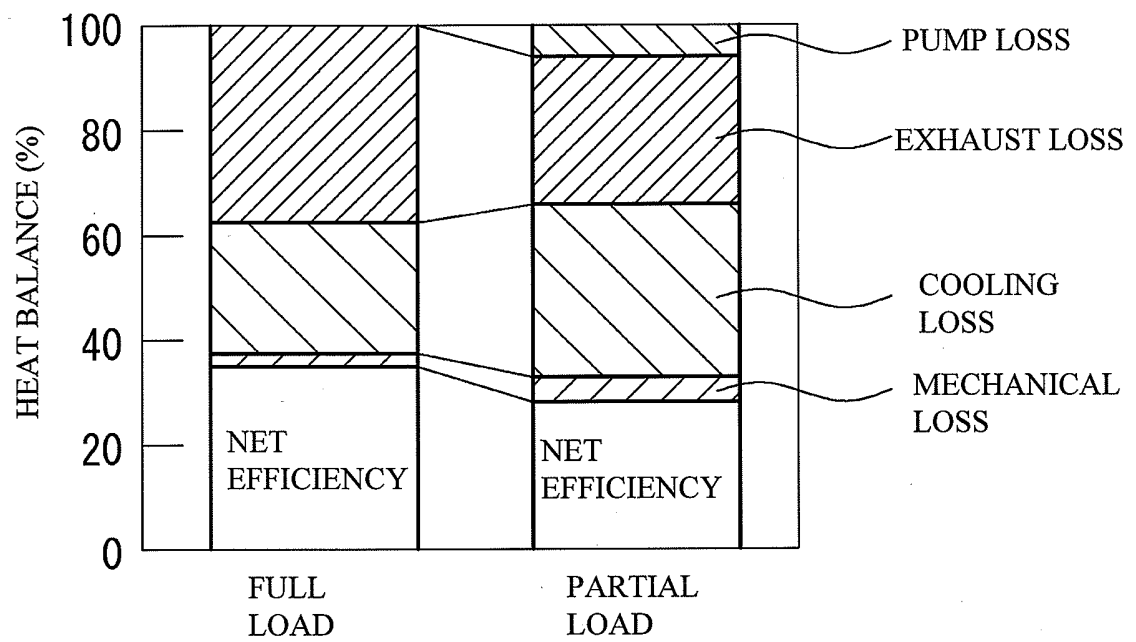
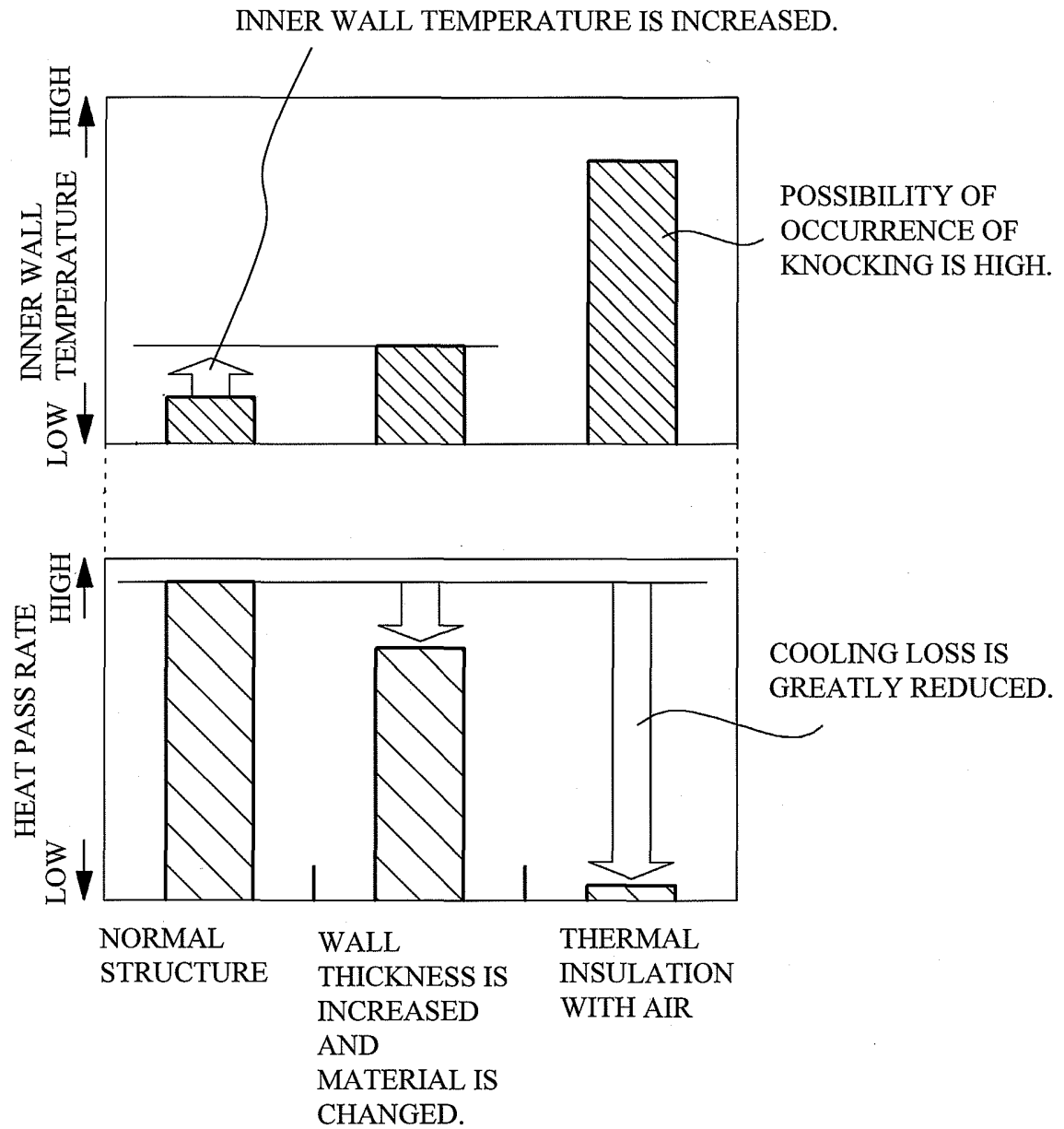


FIG. 14



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2009/070190

A. CLASSIFICATION OF SUBJECT MATTER

F01P7/16(2006.01)i, F02F1/00(2006.01)i, F02F1/36(2006.01)i, F02F1/40
(2006.01)i, F02F11/00(2006.01)i

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)

F01P7/16, F02F1/00, F02F1/36, F02F1/40, F02F11/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2010
Kokai Jitsuyo Shinan Koho	1971-2010	Toroku Jitsuyo Shinan Koho	1994-2010

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2007-247545 A (Nissan Motor Co., Ltd.), 27 September 2007 (27.09.2007), claims 1, 9; paragraphs [0003], [0007], [0081] to [0096]; fig. 11, 12, 14 (Family: none)	1, 2, 4-6
Y	JP 2008-280961 A (Nissan Motor Co., Ltd.), 20 November 2008 (20.11.2008), paragraphs [0012], [0018], [0024], [0025]; fig. 1, 4, 8, 9 (Family: none)	1, 2, 4-6
Y	JP 2007-9826 A (Aichi Machine Industry Co., Ltd.), 18 January 2007 (18.01.2007), paragraphs [0007], [0008]; fig. 4 (Family: none)	5, 6

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

☐ See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-239126 A (Nissan Motor Co., Ltd.), 26 August 2004 (26.08.2004), claim 1; paragraphs [0008], [0009]; fig. 1 to 4 (Family: none)	5, 6
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REFERENCES CITED IN THE DESCRIPTION

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