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(71) Applicant: **Yamada Manufacturing Co., Ltd.**
Kiryu-shi,
Gunma-ken (JP)

(72) Inventors:
- **Koyashiki, Hidehiko**
  Isesaki-shi, Gunma-ken (JP)
- **Koabayashi, Takeshi**
  Isesaki-shi
  Gunma-ken (JP)
- **Mikuni, Takahiro**
  Wako-shi, Saitama-ken 351-0193 (JP)

(74) Representative: **Skone James, Robert Edmund**
Gill Jennings & Every LLP
The Broadgate Tower
20 Primrose Street
London EC2A 2ES (GB)

(54) Engine cooling apparatus

(57) An engine cooling apparatus that is capable of suppressing cavitation in a high rotation region while achieving an increase in a circulation flow rate of cooling water in a low/medium rotation region. The engine cooling apparatus includes: a main cooling water circuit that circulates the cooling water between an engine and a radiator; a branch portion provided between the engine and the radiator; a thermostat; temperature detecting means; a first bypass flow passage; a second bypass flow passage that connects the engine to the branch portion; a control valve; a bypass convergence portion; a water pump; valve opening control means; and engine rotation speed detecting means. predetermined rotation speed, the opening of the control valve is controlled in a fully closed direction from the fully open state.

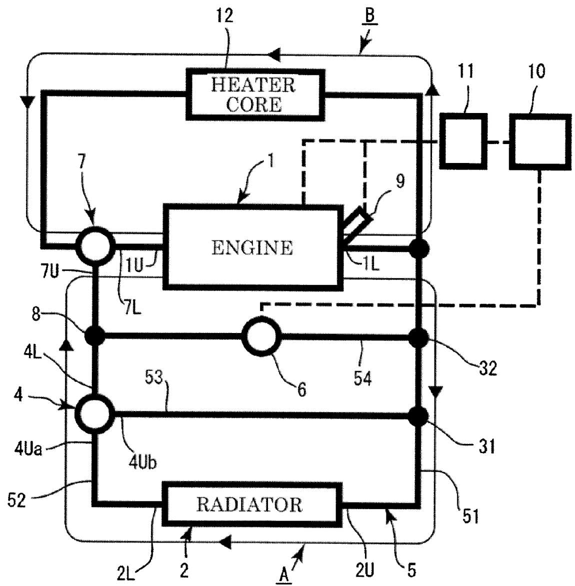

Fig. 1

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Description

[0001] The present invention relates to an engine cooling apparatus that achieves an increase in a circulation flow rate of cooling water in a low/medium rotation region while suppressing cavitation in a high rotation region.

[0002] In a conventional cooling water circuit provided with a bypass circuit for circulating cooling water flowing out of an engine to the engine while bypassing a radiator, two bypass circuits are provided in parallel, a valve is provided in one of the two bypass circuits, and by opening the valve when an engine rotation speed is high in order to reduce a flow passage resistance, an attempt is made to prevent cavitation.

[0003] In Japanese Patent Application Publication No. 2007-100659, for example, a first bypass passage (7) and a second bypass passage (10) are connected in parallel so as to bypass a radiator (2), and a solenoid control valve (11) is disposed at a midway point on the second bypass passage (10). A valve opening of the solenoid control valve (11) is controlled on the basis of an engine rotation speed detected by an engine rotation speed sensor (12). Meanwhile, a flow rate of cooling water flowing through the first bypass passage (7) is controlled by a thermostat (4).

[0004] As a control method, the opening of the solenoid control valve (11) is increased when the engine is in a high rotation region, thereby increasing the flow rate of the cooling water flowing through the second bypass passage (10). Further, the opening of the solenoid control valve (11) is reduced when the engine is in an intermediate rotation region, thereby reducing the flow rate of the cooling water flowing through the second bypass passage (10).

[0005] By employing the configuration and control described above in Japanese Patent Application Publication No. 2007-100659, a cooling capability can be secured in the intermediate rotation region of the engine, while in the high rotation region of the engine, a reduction in flow resistance is achieved by increasing the cooling water flow rate, enabling an increase in a water pressure of the cooling circuit.

[0006] When the cooling water in the cooling water circuit is circulated by a water pump, however, an internal pressure of a suction side flow passage of the water pump typically decreases as a discharge flow rate of the water pump increases. As the pressure decreases, cavitation becomes more likely to occur, and therefore the discharge flow rate of the water pump should not be increased more than necessary.

[0007] With the configuration and control of Japanese Patent Application Publication No. 2007-100659, when a cooling water flow rate required to cool the engine is secured in the intermediate rotation region of the engine, the flow rate of the cooling water flowing through the second bypass passage increases in the high rotation region of the engine. As a result, the internal pressure of the suction side flow passage of the water pump may decrease, leading to an increase in the likelihood of cavitation. If the discharge flow rate of the water pump is reduced to ensure that cavitation does not occur in the high rotation region of the engine, however, knocking becomes more likely to occur when the engine performs a high load operation in a low rotation region, and as a result, an engine output may decrease.

[0008] The present invention has been designed in consideration of these problems, and an object thereof is to provide an engine cooling apparatus that is capable of suppressing cavitation in a high rotation region of an engine while maintaining a cooling capability in an intermediate rotation region of the engine.

[0009] To solve the problems described above, a first aspect of the present invention provides an engine cooling apparatus that solves the problems described above by including: a main cooling water circuit that circulates cooling water between an engine and a radiator; a branch portion provided in the main cooling water circuit between the engine and the radiator; a thermostat provided in the main cooling water circuit between the radiator and the engine on a side where the branch portion is not provided; temperature detecting means for detecting a temperature of the cooling water in the main cooling water circuit; a first bypass flow passage provided between the branch portion and the thermostat; a second bypass flow passage that connects the engine to the branch portion and connects the thermostat to the engine; a control valve provided in the second bypass flow passage; a bypass convergence portion between the main cooling water circuit and the second bypass flow passage; a water pump that is provided between a downstream side of the thermostat and an upstream side of the engine and activated by driving the engine; valve opening control means for controlling an opening of the control valve; and engine rotation speed detecting means for detecting a rotation speed of the engine, wherein, when the temperature of the cooling water is equal to or lower than a predetermined temperature, the first bypass flow passage is set in a circulation state in which the cooling water flows, when the temperature of the cooling water is equal to or higher than the predetermined temperature, the first bypass flow passage is set in a non-circulation state in which the cooling water does not flow, when the engine rotation speed detected by the engine rotation speed detecting means is equal to or lower than a predetermined rotation speed, the control valve is controlled to a fully open state by the valve opening control means, and when the engine rotation speed detected by the engine rotation speed detecting means is equal to or higher than the predetermined rotation speed, the opening of the control valve is controlled by the valve opening control means in a fully closed direction from the fully open state in accordance with an increase in the rotation speed.

[0010] A second aspect according to claim 1 solves the problems described above by providing an engine cooling apparatus that performs control for reducing the predetermined rotation speed as the temperature of the cooling water detected by the temperature detecting means increases.

[0011] With the constitution of the first aspect, when the rotation speed of the engine falls to or below the predetermined rotation speed, the control valve in the second bypass flow passage is set in a fully open state, whereby the second bypass flow passage is set in the circulation state in which the cooling water flows. Accordingly, the flow resistance of the cooling water circuit decreases, leading to an increase in the amount of cooling water circulating through the engine, and as a result, a sufficient cooling performance can be secured and knocking can be suppressed.

[0012] With a conventional device such as that described above, when the rotation speed of the engine increases to a high rotation state while the control valve remains fully open, the discharge flow rate of the water pump becomes excessively large, leading to a reduction in the internal pressure of the flow passage on the water pump suction side, and as a result, cavitation may occur. When the rotation speed of the engine detected by the engine rotation speed detecting means reaches or exceeds the predetermined rotation speed in the present invention, the opening of the control valve is controlled in the fully closed direction in accordance with the increase in the rotation speed. Therefore, when the rotation speed of the engine is in a high rotation region, the flow resistance increases such that the cooling water circulation amount can be suppressed, and as a result, cavitation can be suppressed.

[0013] Further, when the rotation speed of the engine is equal to or higher than the predetermined rotation speed, the control valve is controlled gradually in the fully closed direction from the fully open state in accordance with the increase in the rotation speed, and therefore, in contrast with a case where the control valve is set only in the fully open state and the fully closed state, the flow rate of the cooling water supplied to the engine is appropriate for the rotation speed of the engine. As a result, unnecessary work by the water pump can be eliminated. Furthermore, the first bypass flow passage is not modified from that of the related art, and therefore travel remains possible even if a defect occurs in the second bypass flow passage, albeit with a slightly poorer fuel efficiency.

[0014] With the constitution of the second aspect, the predetermined rotation speed for controlling the opening of the control valve is controlled to be steadily lower as the cooling water temperature rises. Lowering the predetermined rotation speed means lowering the rotation speed of the engine at which control of the control valve in the fully closed direction from the fully open state begins. As the water temperature increases, a rotation speed range in which cavitation occurs tends to shift to a low rotation side, and therefore, by lowering the predetermined rotation speed, cavitation can be suppressed.

[0015] Examples of engine cooling apparatus will now be described with reference to the accompanying drawings, in which:

Fig. 1 is a cooling water circuit diagram illustrating an embodiment of the present invention; and

Fig. 2 is a graph showing an engine rotation speed relative to an engine circulation flow rate when control according to an embodiment of the present invention is performed.

[0016] An embodiment of the present invention will be described below on the basis of the drawings. The present embodiment is a circuit for circulating cooling water between an engine 1 and a radiator 2, which is mainly constituted by a main cooling water circuit A, a first bypass flow passage 53, and a second bypass flow passage 54. A heater circuit B having a flow passage that passes through an engine 1 and a heater core 12 provided in the flow passage is provided in addition to the main cooling water circuit A.

[0017] Fig. 1 shows the cooling water circuit according to an embodiment of the present invention. In the following description, a side of internal components of the cooling water circuit such as the radiator 2 and a thermostat 4 on which the cooling water flows into the components will be referred to as an upstream side and indicated by affixing a reference symbol "U" to the respective components, and a side on which the cooling water flows out of the components will be referred to as a downstream side and indicated by affixing a reference symbol "L" to the respective components (see Fig. 1).

[0018] The main cooling water circuit A is constituted by the engine 1, the radiator 2, and a main flow passage 5. The main flow passage 5 is constituted by a flow passage 51 that connects a downstream side 1L of the engine 1 to an upstream side 2U of the radiator 2, and a flow passage 52 that connects a downstream side 2L of the radiator 2 to an upstream side 1U of the engine 1. The thermostat 4 is provided at a midway point on the flow passage 52 connecting the downstream side 2L of the radiator 2 to the upstream side 1U of the engine 1. Further, a water pump 7 is provided between a downstream side 4L of the thermostat 4 and the upstream side 1U of the engine 1, and temperature detecting means 9 for detecting a temperature of the cooling water is provided in the main cooling water circuit A.

[0019] Furthermore, bypass branch portions 31, 32 (also referred to simply as branch portions 31, 32) are provided at midway points on the flow passage 51 connecting the downstream side 1L of the engine 1 to the radiator upstream side 2U. The first bypass flow passage 53 is provided between one of the bypass branch portions 31 and an upstream side 4U of the thermostat 4 so as to connect the bypass branch portion 31 and the upstream side 4U of the thermostat 4. Further, a bypass convergence portion 8 is provided at a midway point on the flow passage 52 connecting the downstream side 2L of the radiator 2 to the upstream side 1U of the engine 1 and between the downstream side 4L of the thermostat 4 and an upstream side 7U of the water pump 7. The second bypass flow passage 54 is provided between the other bypass branch portion 32 and the bypass convergence portion 8 so as to connect the other bypass branch portion 32 and the bypass convergence portion 8. Valve opening control means 10 and engine rotation speed detecting means 11 are also provided in the main cooling water circuit A, and a control valve 6 that controls a flow rate of the cooling water flowing through the second bypass flow passage 54 in accordance with the valve opening control means 10 is provided at a midway point on the second bypass flow passage 54. When a rotation speed of the engine 1 is detected to be equal to or higher than a predetermined rotation speed (i.e. detected to be high) by the engine rotation speed detecting means 11, the control valve 6 is controlled in a fully closed direction as the rotation speed increases.

[0020] The thermostat 4 is a temperature-sensitive operating valve, and has a function for varying a flow rate ratio between the cooling water flowing through the first bypass flow passage 53 and the cooling water flowing through the radiator 2 in accordance with the temperature of cooling water that flows in from the first bypass flow passage 53, cooling water that flows in through the flow passage 52 after passing through the radiator 2, or cooling water generated when the cooling water that flows in from the first bypass flow passage 53 and the cooling water that flows in from flow passage 52 intermix.

[0021] In Fig. 1, the bypass branch portion 31 is shown to be closer to the radiator 2 than the bypass branch portion 32, but the bypass branch portion 31 and the bypass branch portion 32 are not limited to this positional relationship, and the bypass branch portion 32 may be disposed closer to the radiator 2 than the bypass branch portion 31. Further, the number of branch portions is not limited to two, and the first bypass flow passage 53 may be bifurcated from the second bypass flow passage 54 by a single branch portion. Furthermore, the control performed by the control valve 6 in the second bypass flow passage 54 can be executed in an identical manner to this embodiment even when the bypass branch portion 31 and the thermostat 4 are disposed oppositely, and therefore the bypass branch portion 31 and the thermostat 4 may be disposed oppositely.

[0022] Next, actions of an embodiment of the present invention will be described on the basis of Fig. 2. Fig. 2 is a graph showing characteristics of an embodiment of the present invention. An abscissa of the graph shows the engine rotation speed, and an ordinate shows a circulation flow rate of the cooling water through the engine. A vertical axis shown in a central location of the abscissa is a reference line indicating a predetermined rotation speed of the engine. When the temperature of the cooling water reaches or exceeds a predetermined temperature, the first bypass flow passage 53 enters a non-circulation state in which the cooling water does not flow. Further, when the engine rotation speed detecting means 11 detects that the rotation speed of the engine 1 is equal to or lower than the predetermined rotation speed, the control valve 6 is controlled to a fully open state by the valve opening control means 10, and therefore the second bypass flow passage 54 enters a circulation state in which the cooling water flows. Hence, when the rotation speed of the engine 1 is equal to or lower than the predetermined rotation speed, a flow resistance of the cooling water circuit decreases, leading to an increase in a discharge flow rate of the water pump 7 and a corresponding increase in the amount of cooling water supplied to the engine 1.

[0023] When the second bypass flow passage 54 is in the circulation state, the flow rate of the cooling water to be supplied to the engine 1 is determined in accordance with engine properties such as a knocking capacity of the engine 1. Specifications such as a diameter and a length of the second bypass flow passage 54 are set so that this flow rate is achieved.

[0024] Meanwhile, when the temperature of the cooling water is equal to or higher than the predetermined temperature and the engine rotation speed detecting mans 11 detects that the rotation speed of the engine 1 is equal to or higher than the predetermined rotation speed, the control valve 6 is controlled by the valve opening control means 10 to shift gradually in the fully closed direction from the fully open state as the rotation speed of the engine 1 increases. Hence, the flow rate of the cooling water flowing through the second bypass flow passage 54 can be adjusted in accordance with the variation in the opening of the control valve 6. When the rotation speed of the engine 1 corresponds to a high rotation region, the control valve 6 is fully closed, and therefore the second bypass flow passage 54 enters the non-circulation state in which the cooling water does not flow. As a result, a similar circuit to a cooling water circuit not having the second bypass flow passage is realized.

[0025] In a condition where the temperature of the cooling water is equal to or higher than the predetermined temperature and the engine 1 is in the high rotation region, or in other words when the first bypass flow passage 53 and the second bypass flow passage 54 are in the non-circulation state such that the cooling water flows only through the main flow passage 5, cavitation can be suppressed by setting the flow resistance of the cooling water circuit appropriately. In other words, in a condition where the engine 1 is in the high rotation region and the cooling water flows only through the main flow passage 5, the flow resistance of the main flow passage 5 and so on is preferably increased such that cavitation is less likely to occur.

[0026] Further, as the temperature of the cooling water detected by the temperature detecting means 9 increases, the rotation speed (the predetermined rotation speed) of the engine 1 at which control of the valve opening of the control valve 6 in the fully closed direction from the fully open state begins is modified to a low rotation side. In so doing, cavitation can be suppressed even in a high temperature state.

1	engine
2	radiator
A	main cooling water circuit
31, 32	bypass branch portion
4	thermostat
53	first bypass flow passage
54	second bypass flow passage
7	water pump
8	bypass convergence portion
9	temperature detecting means
10	valve opening control means
11	engine rotation speed detecting means
12	heater core

Claims

1. An engine cooling apparatus comprising:

a main cooling water circuit that circulates cooling water between an engine and a radiator;
a branch portion provided in the main cooling water circuit between the engine and the radiator;
a thermostat provided in the main cooling water circuit between the radiator and the engine on a side where the branch portion is not provided;
temperature detecting means for detecting a temperature of the cooling water in the main cooling water circuit;
a first bypass flow passage provided between the branch portion and the thermostat;
a second bypass flow passage that connects the engine to the branch portion and connects the thermostat to the engine;
a control valve provided in the second bypass flow passage;
a bypass convergence portion between the main cooling water circuit and the second bypass flow passage;
a water pump that is provided between a downstream side of the thermostat and an upstream side of the engine and activated by driving the engine;
valve opening control means for controlling an opening of the control valve; and
engine rotation speed detecting means for detecting a rotation speed of the engine,
wherein, when the temperature of the cooling water is equal to or lower than a predetermined temperature, the first bypass flow passage is set in a circulation state in which the cooling water flows,
when the temperature of the cooling water is equal to or higher than the predetermined temperature, the first bypass flow passage is set in a non-circulation state in which the cooling water does not flow,
when the engine rotation speed detected by the engine rotation speed detecting means is equal to or lower than a predetermined rotation speed, the control valve is controlled to a fully open state by the valve opening control means, and
when the engine rotation speed detected by the engine rotation speed detecting means is equal to or higher than the predetermined rotation speed, the opening of the control valve is controlled by the valve opening control means in a fully closed direction from the fully open state in accordance with an increase in the rotation speed.

2. The engine cooling apparatus according to claim 1, wherein control is performed to reduce the predetermined rotation speed as the temperature of the cooling water detected by the temperature detecting means increases.

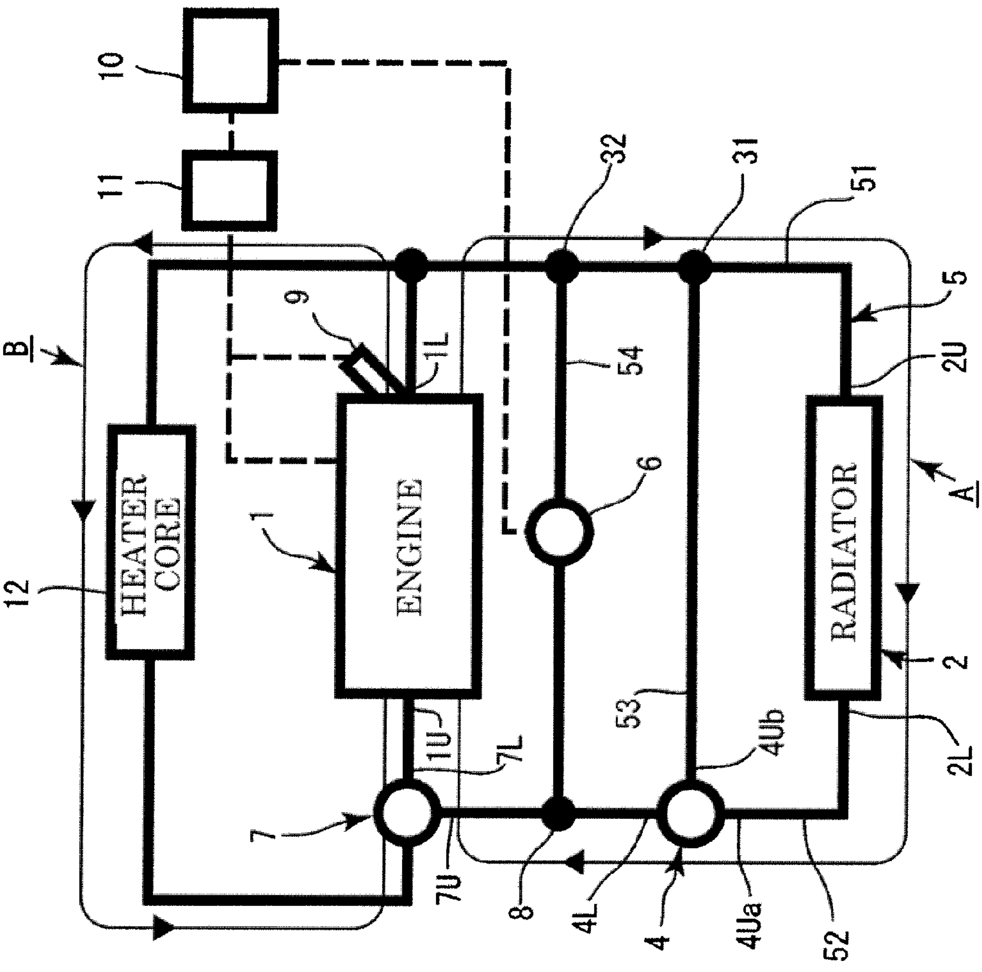
10
11
12
HEATER CORE
B
9
1L
1
ENGINE
1U
7L
7
7U
8
4L
4
4Ua
52
32
31
51
54
6
53
4Ub
5
2U
RADIATOR
A
2
2L

Fig. 1

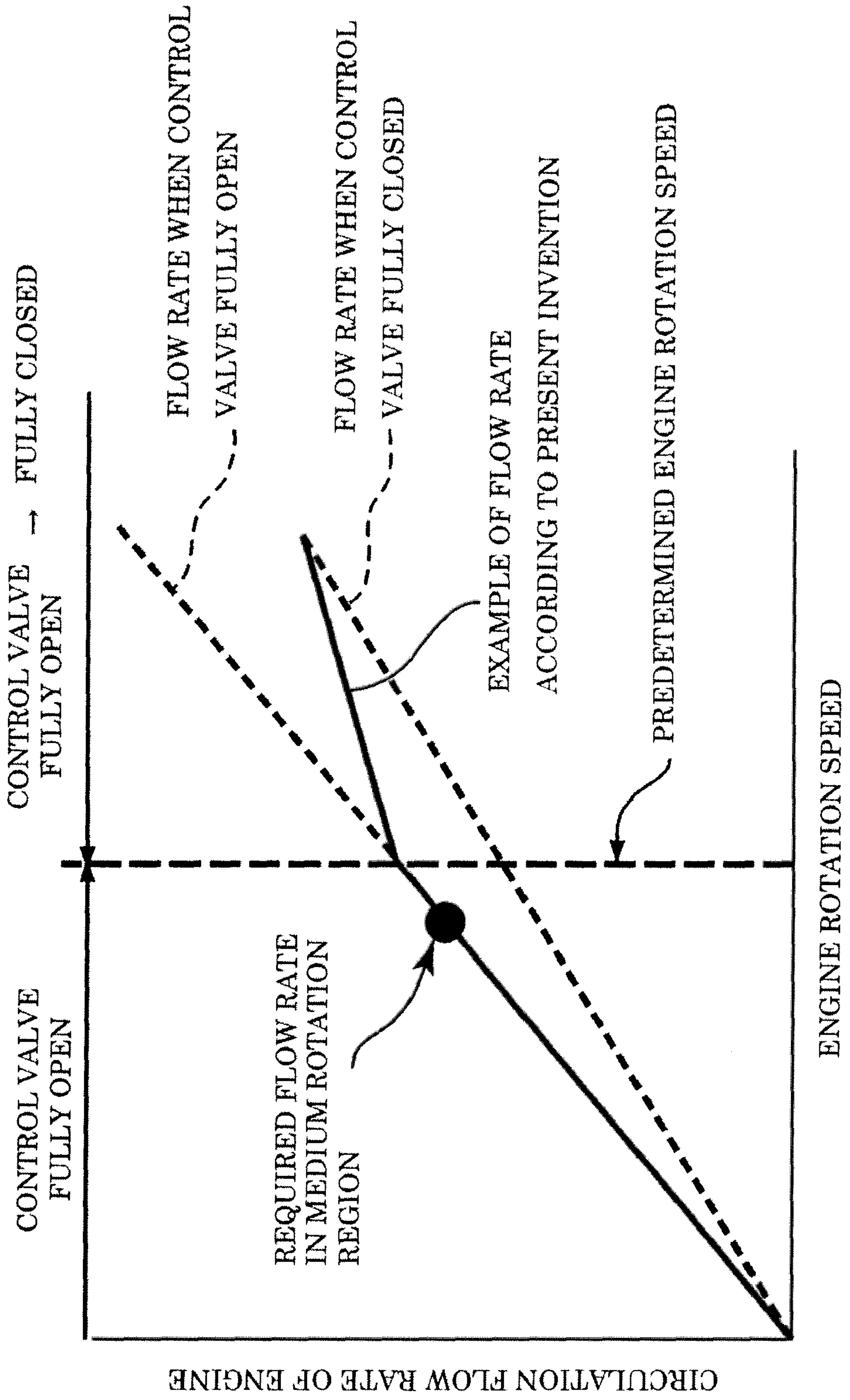
CONTROL VALVE FULLY OPEN
CONTROL VALVE FULLY OPEN → FULLY CLOSED
FLOW RATE WHEN CONTROL VALVE FULLY OPEN
FLOW RATE WHEN CONTROL VALVE FULLY CLOSED
EXAMPLE OF FLOW RATE ACCORDING TO PRESENT INVENTION
PREDETERMINED ENGINE ROTATION SPEED
REQUIRED FLOW RATE IN MEDIUM ROTATION REGION
CIRCULATION FLOW RATE OF ENGINE
ENGINE ROTATION SPEED

Fig.2

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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