(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 715 148 A2

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
25.10.2006 Bulletin 2006/43

(51) Int Cl.:
F01M 11/06 *(2006.01)*

(21) Application number: **06112611.6**

(22) Date of filing: **13.04.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

(30) Priority: **22.04.2005 JP 2005125556**

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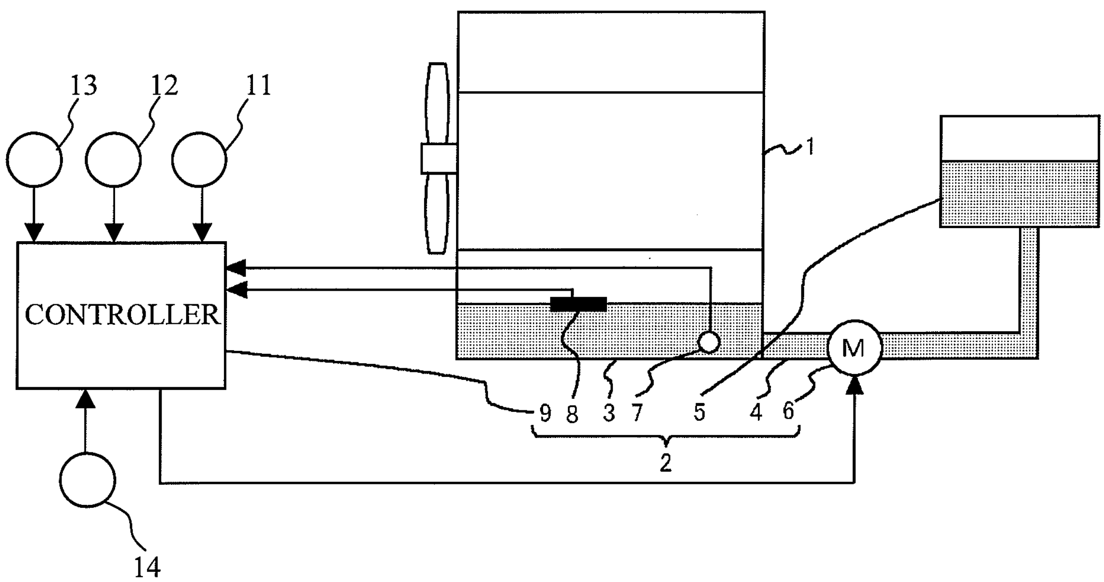
(54) **Engine oil level adjusting apparatus**

(57) In an engine oil level adjusting apparatus including an oil pan (3) provided to a lower portion of an engine main body (1), a sub tank (5) communicating with the oil pan, and oil feeding means (6) for selectively feeding engine oil between the oil pan and the sub tank in both ways, there are provided viscosity measuring means (7) for measuring a viscosity of the engine oil in the oil pan, amount-of-remaining oil detecting means (8) for measuring the amount of engine oil in the oil pan, and control means (9) for determining an appropriate oil level in the oil pan on the basis of the viscosity of engine oil obtained by the viscosity measuring means and for driving the oil feeding means so as to obtain the appropriate oil level.

Fig. 1



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Description

[0001] The present invention relates to an engine oil level adjusting apparatus that adaptively changes the appropriate oil level in the oil pan in accordance with the condition of the engine oil.

[0002] Generally, the engine is equipped with an oil pan, which is provided to a lower portion of the engine and is capable of storing engine oil to be supplied to a lubrication system. The use of an oil makeup apparatus has been proposed in order to hold the appropriate amount of engine oil in the oil pan. The oil makeup apparatus is equipped with a sub tank separate from the oil pan, and is capable of adaptively supplying engine oil in the sub tank to the oil pan in accordance with the amount of engine oil remaining in the oil pan.

[0003] Japanese Patent Application Publication 2-308916 discloses an automatic engine oil makeup apparatus, which maintains a constant amount of engine oil in the oil pan by compensating for variations in the amount of oil fed by an oil feeding device such as a motor. The automatic engine oil makeup apparatus compensates for a decrease in the makeup amount as compared to that at ordinary temperature in association with the oil feeding ability of the oil feeding device such as a motor when the ambient temperature decreases and the engine oil has an increased viscosity. More specifically, the automatic engine oil makeup apparatus detects an engine oil supply environment by referring to given parameters, which may include the engine temperature at the time of engine startup, the engine oil temperature, and the intake air temperature, and determines the driving time of the oil feeding device.

[0004] There is another proposal that copes with an over makeup of engine oil arising from a malfunction of the automatic engine oil makeup apparatus, as described in Japanese Patent Application Publication No. 5-288031.

[0005] The automatic makeup apparatuses disclosed in the applications mentioned above are directed to changing the oil feeding device such as a motor in order to supply engine oil up to the predetermined appropriate oil level. The driving time is determined taking into account the viscosity of the engine oil, which is one of the parameters that reflect the engine oil supply environment. It is thus possible to always hold the engine oil at the predetermined appropriate oil level.

[0006] However, the predetermined appropriate level is fixed regardless of the engine operating condition and oil condition. There is still room for improvement in the setting of the appropriate oil level in terms of improved efficiency in operating the engine.

[0007] The present invention has been made in view of the above-mentioned circumstances and provides an engine oil level adjusting apparatus capable of storing an appropriate amount of engine oil in the oil pan in accordance with the condition of the engine oil.

[0008] According to an aspect of the present invention, there is provided an engine oil level adjusting apparatus including: an oil pan provided to a lower portion of an engine main body; a sub tank communicating with the oil pan; and oil feeding means for selectively feeding engine oil between the oil pan and the sub tank in both ways, characterized by further comprising: viscosity measuring means for measuring a viscosity of the engine oil in the oil pan; amount-of-remaining oil detecting means for measuring the amount of engine oil remaining in the oil pan; and control means for determining an appropriate oil level in the oil pan on the basis of the viscosity of engine oil obtained by the viscosity measuring means and for driving the oil feeding means so as to obtain the appropriate oil level. With this structure, it becomes possible to adaptively increase and decrease the amount of the engine oil in the oil pan on the basis of the current viscosity of the engine oil and to more efficiently operate the engine. When the engine oil touches a crankshaft, the engine oil serves as a resistance to the rotation of a crankshaft and prevents the efficient operation of the engine. It is thus desired to reduce the amount of engine oil to the minimum level required. There is another situation. When the engine oil has a high viscosity, for instance, at the time of cold start, the engine oil is not smoothly returned to the oil pan after the engine oil is sucked from the oil pan and is supplied to parts of the engine lubrication system. It is thus required to store a large amount of engine oil in the oil pan. Further, it is required to supply a large amount of engine oil when the oil temperature is high and the viscosity of the engine oil is lowered, as compared to the amount of engine oil required at ordinary temperature. The supply of a large amount of engine oil is also required to effectively cool the parts of the lubrication system. It is thus required to store a large amount of engine oil in the oil pan when the viscosity of the engine oil is lowered. The engine oil level adjusting apparatus configured as mentioned above is capable of dynamically maintaining the appropriate oil level on the basis of the condition of the engine oil.

[0009] The viscosity measuring means may include an oil temperature sensor attached to the oil pan and handles a sensor output of the oil temperature sensor as data indicating the viscosity of the engine oil, or may a sensor having a sensor output related to the viscosity of engine oil and handles the sensor output as data indicating the viscosity of the engine oil. Although a viscosity sensor capable of directly measuring the viscosity of engine oil may be employed, the present invention avoids the use of such a viscosity sensor. The temperature of engine oil correlates with the viscosity thereof. Thus, the present invention handles the viscosity of engine oil by using the output signal of an oil temperature sensor usually attached to the oil pan. The temperature of a cooling water correlates with the oil temperature, and thus, has a correlation with the viscosity of engine oil. The present invention may be modified so as to handle the viscosity of engine oil by using the output signal of a water temperature sensor. Since the oil temperature or water temperature correlates with the viscosity of engine oil, it may be possible to directly determine the appropriate oil level from the oil temperature or water temperature without actually obtaining the viscosity of engine oil.

[0010] The control means may determine the appropriate oil level so that the appropriate oil level in a first region in which the viscosity of the engine oil is high is set higher than the viscosity of the engine oil in a second region in which the engine oil has a lower viscosity than the viscosity in the first region. Further, the control means may determine the appropriate oil level so that the appropriate oil level in a third region in which the viscosity of the engine oil is lower than that in the second region is set higher than the viscosity of the engine oil in the second region. With these structures, the appropriate oil level is increased, for example, in a cold start in which the engine oil has a high viscosity and there is a difficulty in the return of the engine oil to the oil pan from the lubrication system. It is thus possible to avoid shortage of the engine oil. When the engine is warmed up or the environment is at the ordinary temperature, the appropriate oil level is set low in order to reduce the degree of touch of the engine oil with the crankshaft and reduce the friction therebetween. This improves fuel economy. When the engine oil is at a high temperature and has a lowered viscosity in which the engine has a heavy load or rotates fast, the appropriate oil level is increased to avoid shortage of engine oil in the oil pan.

[0011] The control means may determine the appropriate oil level so that the appropriate oil level in the first region is set higher than that in the third region. This structure takes into account the fact that the amount of engine oil needed when the oil temperature becomes high and the viscosity of engine oil is lowered is greater than that needed when the engine oil has a high viscosity and has difficulty in returning to the oil pan from the parts of the lubrication system.

[0012] The viscosity measuring means may measure the viscosity of the engine oil by referring to an engine speed and/or an engine load. The control means may increase the appropriate oil level as the viscosity of the engine oil decreases. For example, after the completion of warming up, the oil temperature rises and the viscosity of the engine oil decreases as the engine load or speed increase. In these cases, it is required to supply a large amount of engine oil to the lubrication system of the engine. According to the present invention, the appropriate oil level is raised to store an increased amount of engine oil in the oil pan in accordance with the engine load and/or speed. It is possible to directly determine the appropriate oil level from the engine load and/or speed without directly obtaining the viscosity of the engine oil therefrom.

[0013] Other objects, features and advantages of the present invention will become more apparent from the following detailed description when read in conjunction with the following drawings, in which:

Fig. 1 is a block diagram of an engine main body into which an engine oil level adjusting apparatus is incorporated in accordance with a first embodiment of the present invention;

Fig. 2 is a flowchart of a sequence for determining a vehicle horizontal state in which an oil level control is carried out;

Fig. 3 is a flowchart of the oil level control in accordance with the first embodiment of the present invention;

Fig. 4 is a graph of a relationship between an oil temperature (THO) and an appropriate oil level;

Fig. 5 is a flowchart of another oil level control in accordance with a second embodiment of the present invention; and

Fig. 6 is a graph of a relationship between an engine speed/load and the appropriate oil level.

[0014] Fig. 1 shows a first embodiment of the present invention in which an engine oil level adjusting apparatus 2 is incorporated into an engine main body 1. The engine oil level adjusting apparatus 2 has an oil pan 3 and a sub tank 5. The oil pan 3 is provided to a lower portion of the engine main body 1. The sub tank 5 communicates with the oil pan 3 via a joining pipe 4. An oil feeding motor 6, which functions as oil feeing means, is attached to the joining pipe 4. An oil temperature sensor 7 and an oil level sensor 8 are attached to the oil pan 3. The oil temperature senor 7 functions as viscosity measuring means, and the oil level sensor 8 functions as amount-of-remaining oil detecting means. The oil temperature sensor 7 and the oil level sensor 8 are connected to a controller 9, which serves as control means and is connected to the oil feed motor 6. The motor 6 allows the oil pan 3 and the sub tank 5 to selectively communicate with each other in both ways. The controller 9 may be an electronic control unit.

[0015] The engine oil level adjusting apparatus performs the following oil level control. It is preferably required that the vehicle is in the horizontal state in order to accurately measure the oil level in the oil pan 3. The controller 9 determines whether an oil level control should be executed in accordance with a flowchart of Fig. 2. At step S11, the controller 9 refers to an output signal of a horizontal sensor 11, and determines whether the vehicle is in the horizontal state. When the answer of step S11 is YES, the controller 9 performs the oil level control using the engine oil level adjusting apparatus 2 at step S12. In contrast, when the answer of step S11 is NO, the controller 9 does not execute the oil level control by the engine oil level adjusting apparatus 2 (step S13).

[0016] When it is determined that the vehicle is in the horizontal state and the oil level control can be executed in the above-mentioned sequence, the controller 9 executes the oil level control in accordance with a flowchart of Fig. 3. At step S21, the controller 9 determines whether an ignition switch 12 (Fig. 1) connected to the controller 9 is in the ON state. When the answer of step S21 is YES, the controller 9 refers to the output signals of the oil temperature sensor 7 and the oil level sensor 8, and acquires the temperature THO of the engine oil in the oil pan 3 and the current oil level at step S22. At step S23, the controller 9 refers to a map with the oil temperature THO, and obtains the appropriate oil level.

[0017] The map to be referred to at step S23 will now be described with reference to Fig. 4. The map has map values obtained from a graph of Fig. 4 and stored in, for example, the controller 9. The horizontal axis of the graph denotes the oil temperature THO, and the vertical axis thereof denotes the appropriate oil level in the oil pan 3. The horizontal axis may be an address with which the map may be accessed, and the vertical axis may be the contents of the map. The use of the oil temperature THO is based on the fact that the viscosity of the engine oil has a correlation with the oil temperature THO. As shown in the graph, the oil temperature THO is sectioned into three regions, namely, the first, second and third regions. In the first region, the engine oil has a high viscosity in an extremely cold state and the engine oil supplied to the engine main body 1 is not smoothly returned to the oil pan 3. Thus, the appropriate oil level L1 in the oil pan 3 is the highest in the first region. In the second region, the ambient is at the ordinary temperature and the engine warming up is completed. In the second region, the engine oil supplied to the engine main body 1 may be smoothly returned to the oil pan 3. Therefore, it is not necessary to consider the return of the engine oil. The appropriate oil level L2 in the second region is mainly intended to reduce the friction between the crankshaft and the engine oil, and is thus the lowest. In the third region, the engine oil is at a relatively high temperature at which the engine oil has a lowed viscosity. A large amount of engine oil having a lowed viscosity is needed to be supplied to the engine main body 1 to secure sufficient lubrication performance by the lowered viscosity of the engine oil. Thus, the appropriate oil level L3 in the third region is set higher than the appropriate oil level L2 in the second region. It should be noted that the appropriate oil level L3 is set slightly lower than the appropriate oil level L1 in the first region. This is because the second appropriate level L2 is selected by taking into account both reduction in friction between the crankshaft and the engine oil and the lubrication performance.

[0018] At step S23, the controller 9 determines the appropriate oil level by referring to the map values stored in the controller 9 with the engine oil temperature THO obtained at step S22. At step S24, the controller 9 compares the current oil level obtained at step S22 with the appropriate oil level obtained at step S23, and determines whether the appropriate oil level is equal to the current oil level. When the answer of step S24 is YES, the controller 9 ends the control. On the contrary, when the answer of step S24 is NO, the controller 9 proceeds to step S25.

[0019] At step S25, the controller 9 determines whether the current oil level obtained at step S22 is greater than the appropriate oil level obtained at step S23. When the answer of step S25 is YES, that is, when the current oil level is lower than the appropriate oil level, the controller 9 executes step S26. At step S26, the controller 9 causes the oil feeding motor 6 to rotate forwardly so that the oil is fed to the oil pan 3 from the sub tank 5. In contrast, when the answer of step S25 is NO, that is, the current oil level is higher than the appropriate oil level obtained at step S23, the controller 9 executes step S27. At step S27, the controller 9 causes the oil feeding motor 6 to rotate backwardly so that the oil is fed to the sub tank 5 from the oil pan 3. Step S26 or step S27 is followed by step S24. By the above-mentioned sequence, the appropriate oil level can be always maintained.

[0020] A description will now be given of a second embodiment of the present invention, which employs a different oil level control from that of the first embodiment. The oil level control of the second embodiment is shown in a flowchart of Fig. 5.

[0021] At step S31, the controller 9 determines whether the engine has been warmed up. This determination may refer to the temperature of cooling water. After the engine is warmed up, the controller 9 executes at step S32 and reads the output signals of an engine speed sensor 13 (Fig. 1), a throttle sensor 14 (Fig. 1) and the oil level sensor 8. The controller 9 obtains the engine speed, the engine load and the current oil level from the sensor output signals. At step S33 subsequent to step S32, the controller 9 refers to the map values stored in the controller 9 with the engine speed and the engine load, and thus obtains the appropriate oil level.

[0022] The map values used in step S33 may be created based on a graph of Fig. 6. The horizontal axis of the graph denotes the engine speed and load, and the vertical axis thereof denotes the appropriate oil level in the oil pan 3. The engine speed/load is relatively high on the right-hand side of the horizontal axis and is relatively low on the left-hand side thereof. The graph of Fig. 6 shows that the appropriate oil level becomes higher as the engine speed/load becomes higher.

[0023] At step S33, the controller 9 determines the appropriate oil level using the map values. At step S34, the controller 9 compares the current oil level obtained at step S32 with the appropriate oil level obtained at step S33, and determines whether the appropriate oil level is equal to the current oil level. When the answer of step S34 is YES, the controller 9 ends the control. On the contrary, when the answer of step S34 is NO, the controller 9 proceeds to step S35.

[0024] At step S35, the controller 9 determines whether the current oil level obtained at step S32 is greater than the appropriate oil level obtained at step S33. When the answer of step S35 is YES, that is, when the current oil level is lower than the appropriate oil level, the controller 9 executes step S36. At step S36, the controller 9 causes the oil feeding motor 6 to rotate forwardly so that the oil is fed to the oil pan 3 from the sub tank 5. In contrast, when the answer of step S35 is NO, that is, the current oil level is higher than the appropriate oil level obtained at step S33, the controller 9 executes step S37. At step S37, the controller 9 causes the oil feeding motor 6 to rotate backwardly so that the oil is fed to the sub tank 5 from the oil pan 3. Step S36 or step S37 is followed by step S34. By the above-mentioned sequence, the appropriate oil level can be always maintained.

[0025] The present invention is not limited to the specifically disclosed embodiments, but includes other embodiments, variations and modifications within the scope of the present invention. For example, the temperature of cooling water may be used instead of the oil temperature THO as a parameter for the oil level control. The water temperature has a correlation with the oil temperature THO.

[0026] In an engine oil level adjusting apparatus including an oil pan (3) provided to a lower portion of an engine main body (1), a sub tank (5) communicating with the oil pan, and oil feeding means (6) for selectively feeding engine oil between the oil pan and the sub tank in both ways, there are provided viscosity measuring means (7) for measuring a viscosity of the engine oil in the oil pan, amount-of-remaining oil detecting means (8) for measuring the amount of engine oil in the oil pan, and control means (9) for determining an appropriate oil level in the oil pan on the basis of the viscosity of engine oil obtained by the viscosity measuring means and for driving the oil feeding means so as to obtain the appropriate oil level.

Claims

1. An engine oil level adjusting apparatus including:

an oil pan provided to a lower portion of an engine main body;
a sub tank communicating with the oil pan; and
oil feeding means for selectively feeding engine oil between the oil pan and the sub tank in both ways, **characterized by** further comprising:

viscosity measuring means for measuring a viscosity of the engine oil in the oil pan;
amount-of-remaining oil detecting means for measuring the amount of engine oil remaining in the oil pan; and
control means for determining an appropriate oil level in the oil pan on the basis of the viscosity of engine oil obtained by the viscosity measuring means and for driving the oil feeding means so as to obtain the appropriate oil level.

2. The engine oil level adjusting apparatus as claimed in claim 1, **characterized in that** the viscosity measuring means includes an oil temperature sensor attached to the oil pan and handles a sensor output of the oil temperature sensor as data indicating the viscosity of the engine oil.

3. The engine oil level adjusting apparatus as claimed in claim 1, **characterized in that** the viscosity measuring means includes a sensor having a sensor output related to the viscosity of engine oil and handles the sensor output as data indicating the viscosity of the engine oil.

4. The engine oil level adjusting apparatus as claimed in claim 1 or 2, **characterized in that** the control means determines the appropriate oil level so that the appropriate oil level in a first region in which the viscosity of the engine oil is high is set higher than the viscosity of the engine oil in a second region in which the engine oil has a lower viscosity than the viscosity in the first region.

5. The engine oil level adjusting apparatus as claimed in claim 4, **characterized in that** the control means determines the appropriate oil level so that the appropriate oil level in a third region in which the viscosity of the engine oil is lower than that in the second region is set higher than the viscosity of the engine oil in the second region.

6. The engine oil level adjusting apparatus as claimed in claim 5, **characterized in that** the control means determines the appropriate oil level so that the appropriate oil level in the first region is set higher than that in the third region.

7. The engine oil level adjusting apparatus as claimed in claim 1, **characterized in that** the viscosity measuring means measures the viscosity of the engine oil by referring to an engine speed and/or an engine load.

8. The engine oil level adjusting apparatus as claimed in claim 7, **characterized in that** the control means increases the appropriate oil level as the viscosity of the engine oil decreases.

Fig. 1

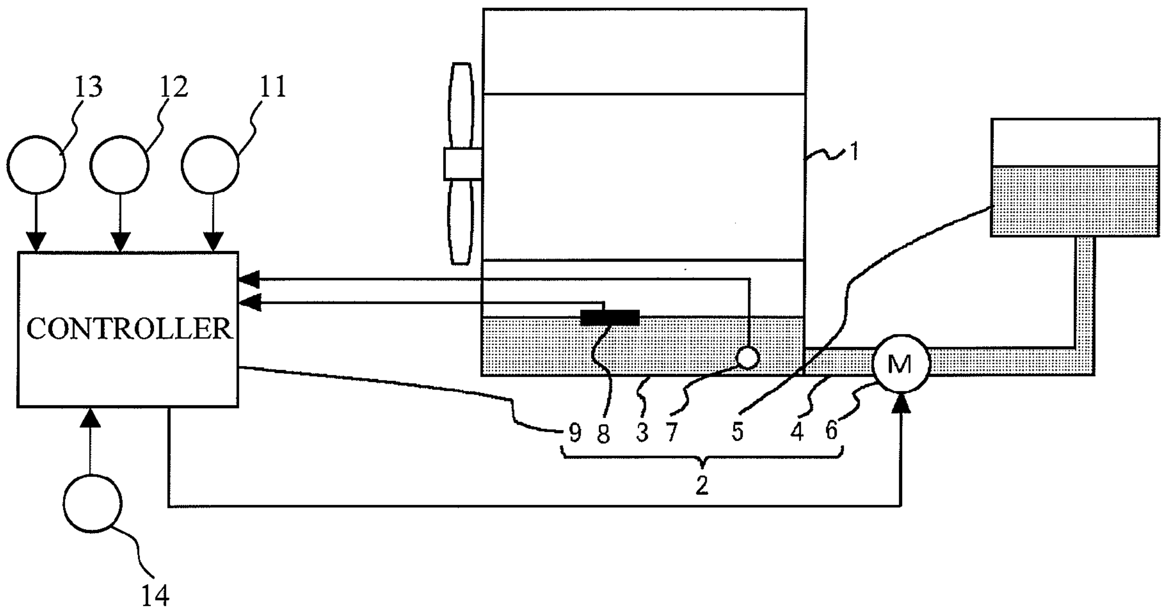


Fig. 2

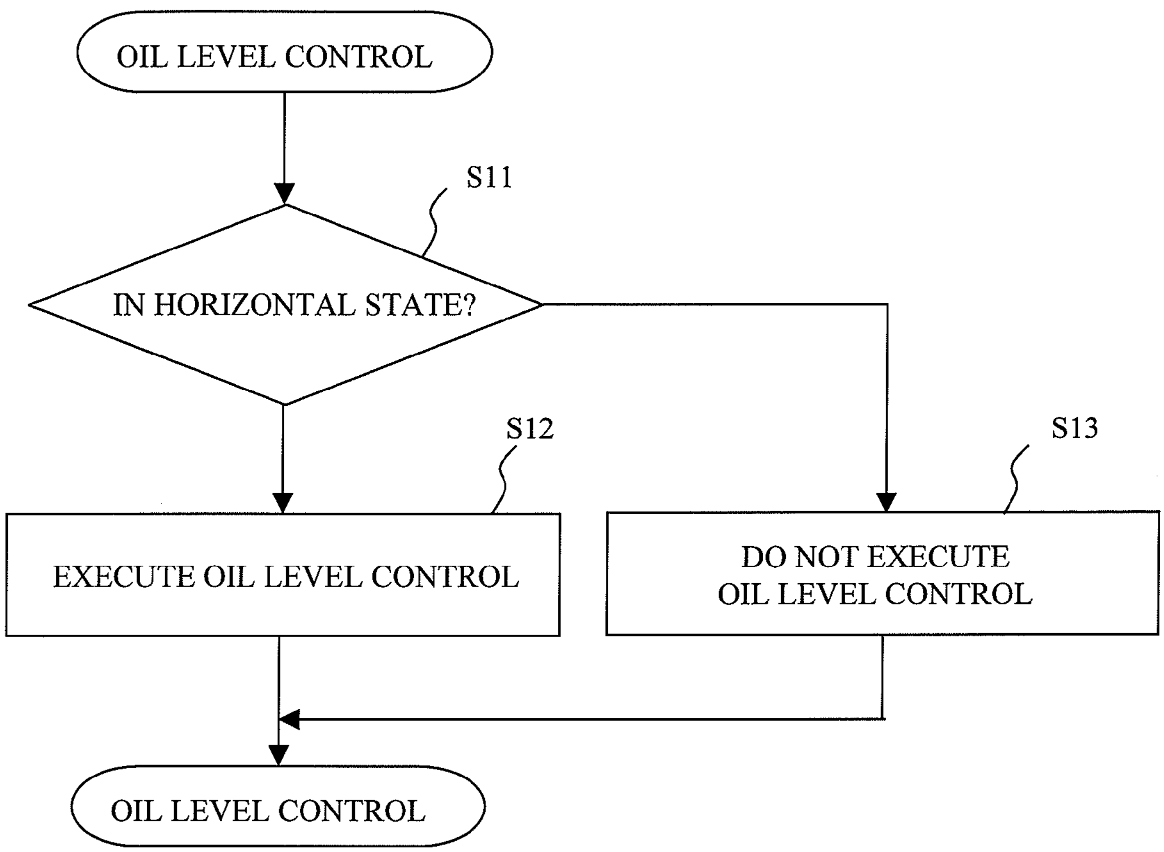

OIL LEVEL CONTROL
S11
IN HORIZONTAL STATE?
S12
S13
EXECUTE OIL LEVEL CONTROL
DO NOT EXECUTE
OIL LEVEL CONTROL
OIL LEVEL CONTROL

Fig. 3

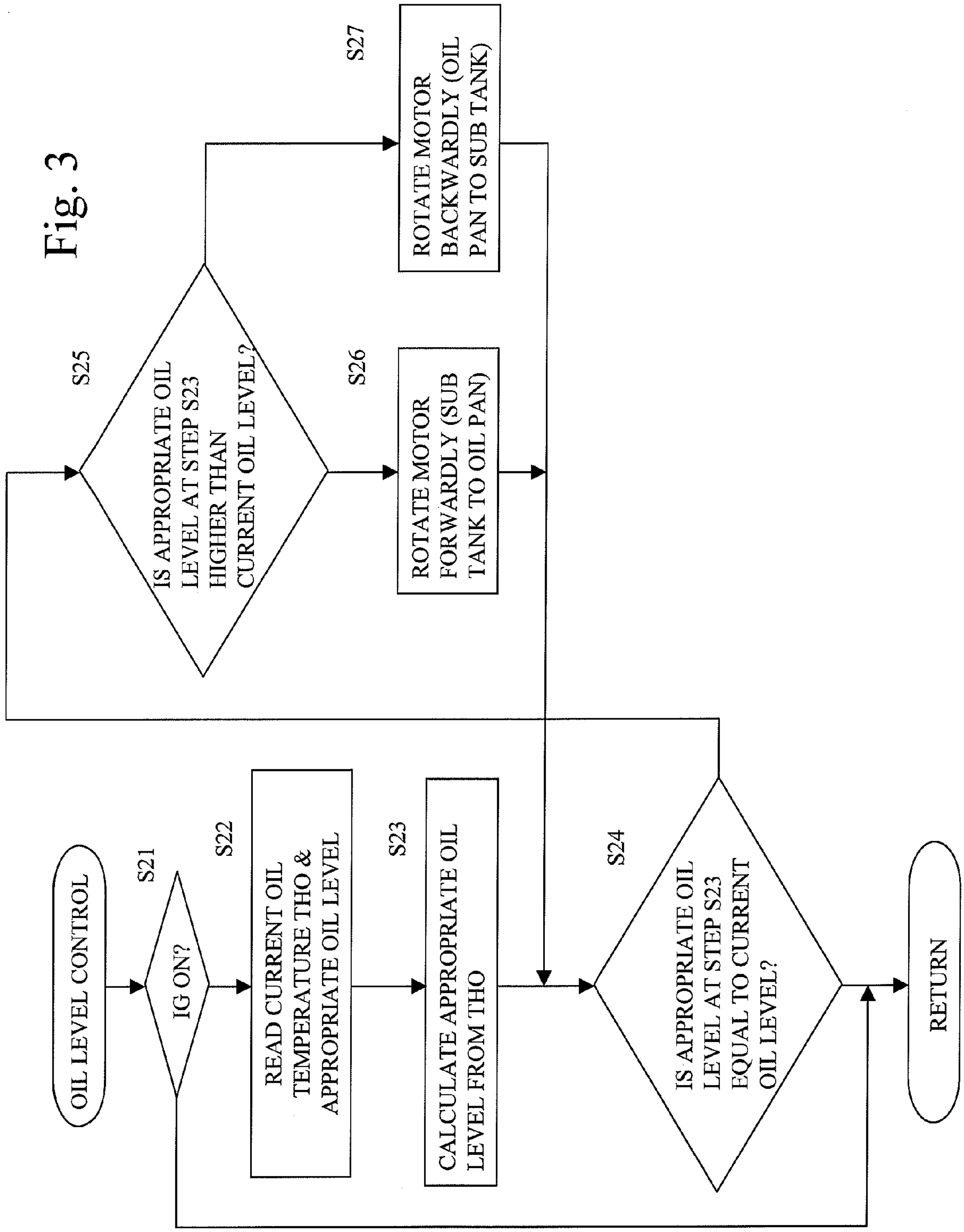

OIL LEVEL CONTROL
S21
IG ON?
S22
READ CURRENT OIL TEMPERATURE THO & APPROPRIATE OIL LEVEL
S23
CALCULATE APPROPRIATE OIL LEVEL FROM THO
S24
IS APPROPRIATE OIL LEVEL AT STEP S23 EQUAL TO CURRENT OIL LEVEL?
RETURN
S25
IS APPROPRIATE OIL LEVEL AT STEP S23 HIGHER THAN CURRENT OIL LEVEL?
S26
ROTATE MOTOR FORWARDLY (SUB TANK TO OIL PAN)
S27
ROTATE MOTOR BACKWARDLY (OIL PAN TO SUB TANK)

Fig. 4

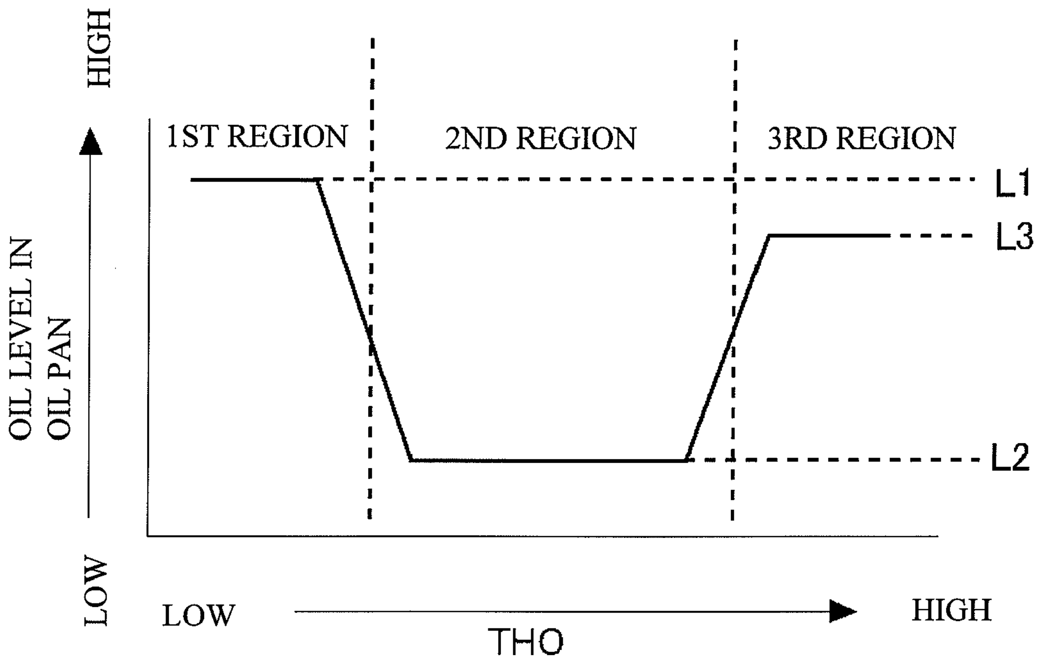
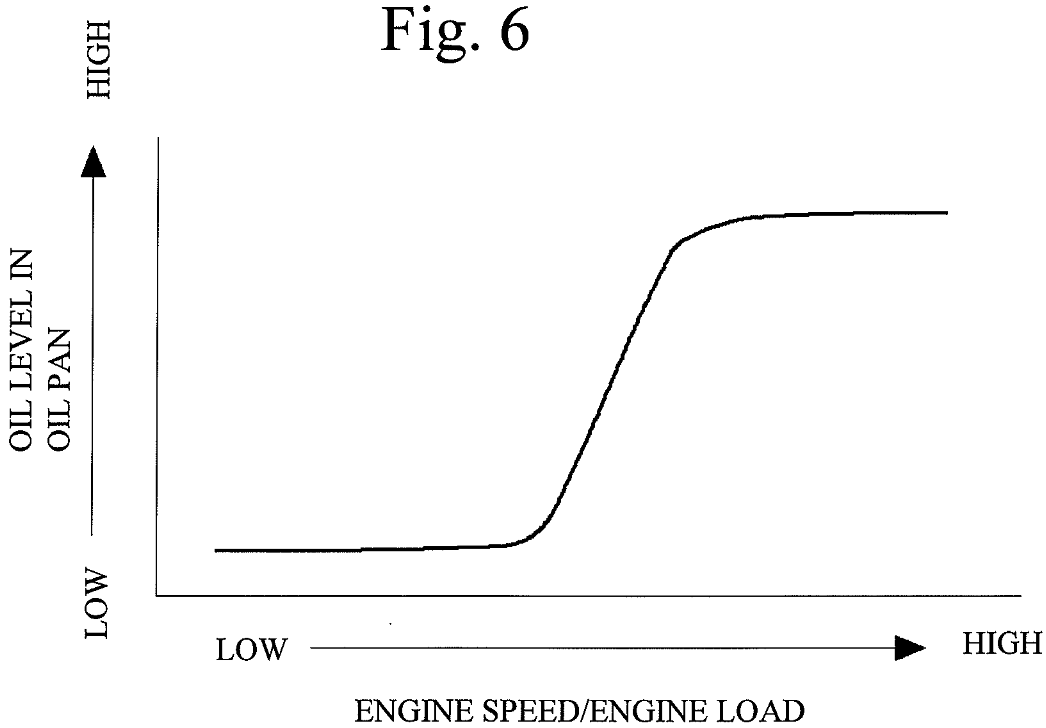

HIGH
OIL LEVEL IN
OIL PAN
LOW
1ST REGION
2ND REGION
3RD REGION
L1
L3
L2
LOW
THO
HIGH

Fig. 6


HIGH
OIL LEVEL IN
OIL PAN
LOW
LOW
HIGH
ENGINE SPEED/ENGINE LOAD

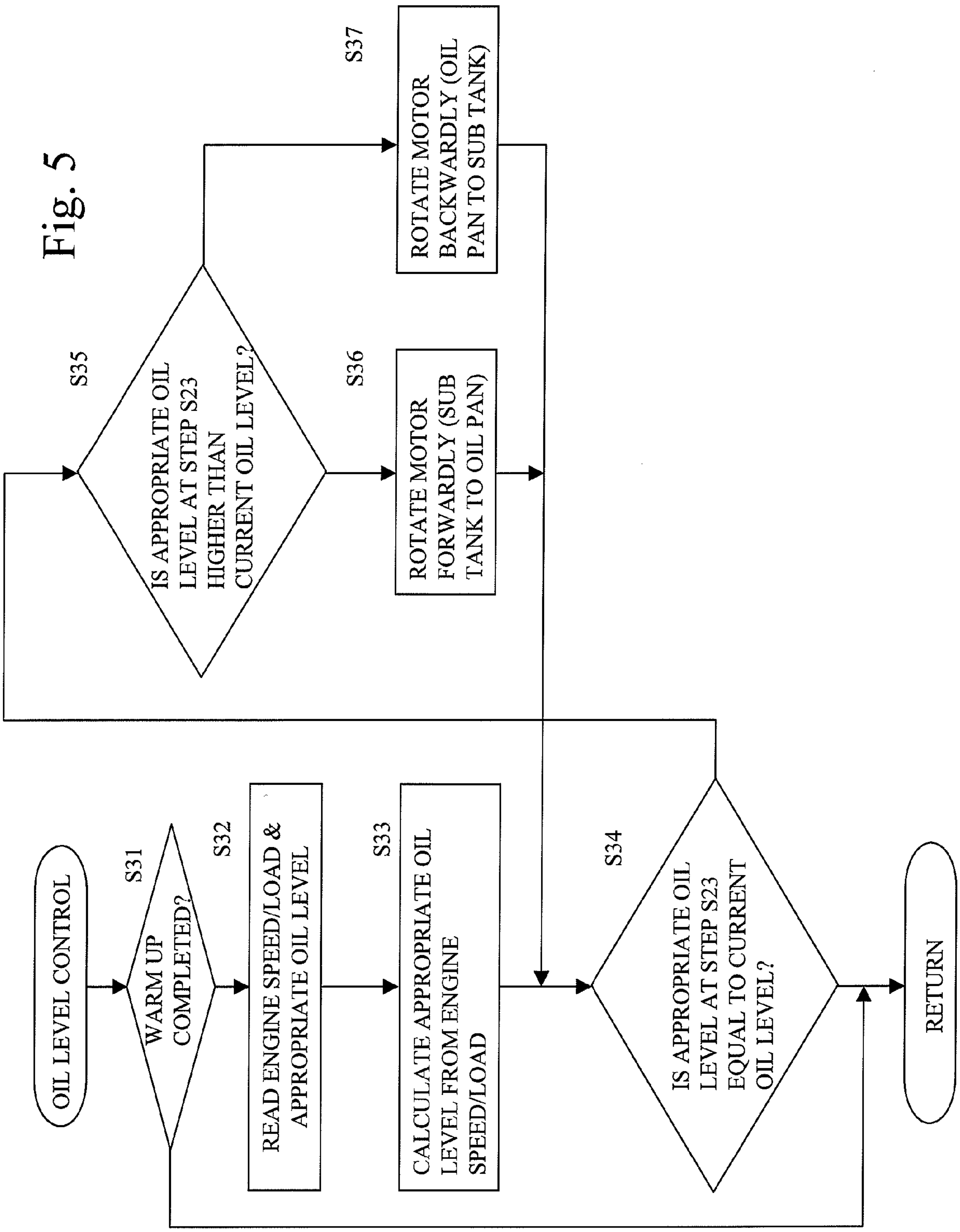

OIL LEVEL CONTROL
S31
WARM UP COMPLETED?
S32
READ ENGINE SPEED/LOAD & APPROPRIATE OIL LEVEL
S33
CALCULATE APPROPRIATE OIL LEVEL FROM ENGINE SPEED/LOAD
S34
IS APPROPRIATE OIL LEVEL AT STEP S23 EQUAL TO CURRENT OIL LEVEL?
RETURN
S35
IS APPROPRIATE OIL LEVEL AT STEP S23 HIGHER THAN CURRENT OIL LEVEL?
S36
ROTATE MOTOR FORWARDLY (SUB TANK TO OIL PAN)
S37
ROTATE MOTOR BACKWARDLY (OIL PAN TO SUB TANK)

Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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- JP 5288031 A **[0004]**