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(72) Inventor: **Saotome, Yoshimi**
KOBELCO CONSTR. MACHIN. CO., LTD.
Hiroshima-shi
Hiroshima 731-0138 (JP)

(74) Representative: **TBK-Patent**
Bavariaring 4-6
80336 München (DE)

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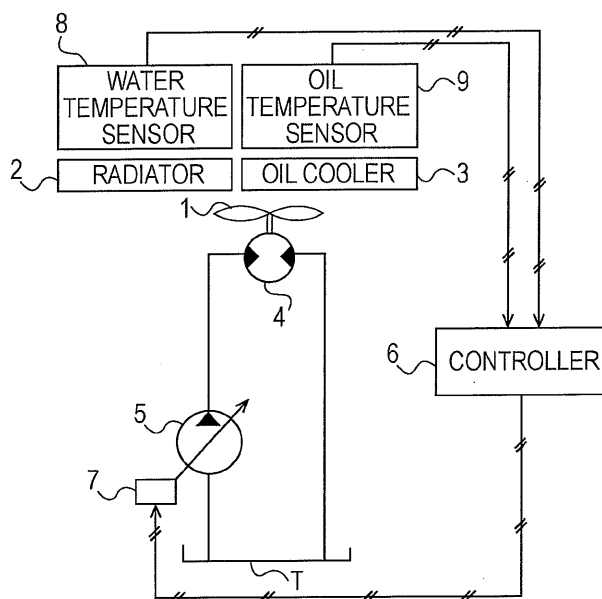
(71) Applicant: **KOBELCO CONSTRUCTION MACHINERY CO., LTD.**
Hiroshima-shi,
Hiroshima 731-0138 (JP)

(54) **Controlling system for cooling fan**

(57) A controlling system for a cooling fan according to the present invention includes a fluid-pressure motor for driving the cooling fan; a fluid-pressure pump functioning as a driving source for the fluid-pressure motor; and a controller. The controller determines a target motor speed value by selecting a higher one of required motor speed values respectively corresponding to multiple kinds of fluids to be cooled and controls the fluid-pressure

motor so that the motor speed thereof reaches the target motor speed value, each of the required motor speed values being determined from a temperature value of the corresponding fluid detected by a corresponding one of temperature sensors on the basis of a characteristic preliminarily determined by a temperature-versus-motor-speed relationship for the corresponding fluid, the characteristic being set for each kind of fluid.

FIG. 1



Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates to controlling systems for cooling fans that are driven by hydraulic motors.

2. Description of the Related Art

[0002] For example, Japanese Patent No. 3238775 discusses a technique for preventing a waste of energy in a driving system of a hydraulic motor that rotates a cooling fan of an engine cooling device and a working-oil cooling device disposed in a hydraulic excavator. Specifically, this is achieved by switching the rotational speed of the hydraulic motor between high and low speed modes in accordance with the temperature of fluid to be cooled.

[0003] According to this technique, the motor is rotated at high speed when the temperature values of coolant water and working oil for the motor are higher than a predetermined temperature value, whereas the motor is rotated at low speed when these temperature values are lower than the predetermined temperature value.

[0004] However, since a control operation in this technique is performed only for increasing or decreasing the fan speed, there is a drastic change in the fan speed in response to the control operation.

[0005] Especially in hydraulic excavators, even if an excavator is operated to perform the same kind of operation for a certain period of time, the motor speed may change drastically within that period depending on the content (load) of the work. This may cause a drastic change in fan noise in response to each changing of the motor speed, giving an operator a feeling of insecurity and unpleasantness.

[0006] Moreover, the drastic change in the motor speed between the high and low speed modes leads to a large fluctuation of engine power spent for the cooling fan. Since this significantly changes the power (engine power, fan power) that can be used for the operation of the excavator, the operating speed of attachment components is changed, thus impairing the workability of the excavator.

SUMMARY OF THE INVENTION

[0007] Accordingly, it is an object of the present invention to provide a controlling system for a cooling fan in which the fan speed is properly controlled in accordance with the temperature of fluid to be cooled while inhibiting the fan speed from fluctuating drastically.

[0008] A controlling system for a cooling fan according to the present invention has the following basic structure.

[0009] Specifically, the controlling system for the cooling fan includes a fluid-pressure motor for driving the

cooling fan; a fluid-pressure pump functioning as a fluid-pressure source for the fluid-pressure motor; temperature sensors for detecting temperature values of multiple kinds of fluids to be cooled; and motor-speed controlling means for controlling a rotational speed of the fluid-pressure motor. The motor-speed controlling means determines a target motor speed value by selecting a higher one of required motor speed values respectively corresponding to the fluids and controls the fluid-pressure motor so that the motor speed thereof reaches the target motor speed value, each of the required motor speed values being determined from the temperature value of the corresponding fluid detected by the corresponding temperature sensor on the basis of a characteristic preliminarily determined by a temperature-versus-motor-speed relationship for the corresponding fluid, the characteristic being set for each kind of fluid.

[0010] According to the present invention, the temperature-versus-motor-speed characteristics are preliminarily determined respectively for the multiple kinds of fluids to be cooled. A higher one of the motor speed values (fan speed values), which are determined on the basis of the detected temperature values of the fluids, is selected as a target value. The fluid-pressure motor is thus controlled so that the motor speed thereof reaches the target value. Accordingly, in contrast to the related art in which the speed control is performed by selecting between two speed modes of high speed and low speed, a speed control operation according to the present invention allows for smaller speed changes in association with changes in fluid temperature, that is, a required cooling capability.

[0011] Accordingly, this reduces a drastic change in fan noise and stabilizes the operating power by reducing a drastic fluctuation of consumption power for driving the cooling fan.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

Fig. 1 is a block diagram of a controlling system for a cooling fan according to a first embodiment of the present invention;

Fig. 2 is a graph showing a characteristic determined by a relationship between water temperature and required motor speed, which is set and stored in a controller provided in the controlling system;

Fig. 3 is a graph showing a characteristic determined by a relationship between oil temperature and required motor speed, which is set and stored in the controller provided in the controlling system;

Fig. 4 is a block diagram of an engine cooling device and shows a set position of a water temperature sensor;

Fig. 5 is a block diagram illustrating a controlling system according to a second embodiment of the present invention; and

Fig. 6 is a graph showing a characteristic determined by a relationship between oil temperature and required motor speed, which is set and stored in the controller provided in the controlling system according to the second embodiment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] A description below is directed to an example in which the present invention is applied to a hydraulic excavator that is driven hydraulically with, for example, fluid pressure. A hydraulic excavator is equipped with, for example, an engine cooling device for cooling an engine; a working-oil cooling device for cooling working oil that is used for actuating a hydraulic actuator serving as a fluid-pressure actuator; and a cabin cooling device for cooling the interior of a cabin. Moreover, these cooling devices are individually provided with cooling fans, or are provided with a common cooling fan. A cooling fan is rotated by a hydraulic motor serving as a fluid-pressure motor that is driven hydraulically with a hydraulic pump serving as a fluid-pressure pump. A controlling system for a cooling fan according to the present invention is used for such a cooling fan.

[0014] A controlling system for a cooling fan according to an exemplary embodiment of the present invention will now be described with reference to the drawings.

[0015] In each of the embodiments which will be described below, water is used as a coolant, working oil is used as a working fluid for driving the fluid-pressure actuator, and a radiator is used as a coolant cooler for cooling the coolant.

[0016] A first embodiment of the present invention will be described below with reference to Figs. 1 to 4.

[0017] Fig. 1 illustrates an example in which a radiator 2 serving as the engine cooling device and an oil cooler 3 serving as the working-oil cooling device are cooled with a single cooling fan 1. Therefore, in this example, fluids to be cooled include working oil and coolant water for the radiator 2.

[0018] In Fig. 1, a hydraulic motor 4 is provided for driving the cooling fan 1, and a variable-displacement hydraulic pump 5 is provided as a hydraulic source for the hydraulic motor 4. Moreover, a controller 6 and a pump regulator 7 define speed controlling means for controlling the rotational speed of the hydraulic motor 4. In some cases, the rotational speed will be referred to as a fan speed hereinafter.

[0019] Specifically, the pump regulator 7 is actuated in response to a command signal from the controller 6, by which the capacity of the hydraulic pump 5 is adjusted. Thus, the pump pressure is controlled, thereby changing the motor speed of the hydraulic motor 4.

[0020] Furthermore, a water temperature sensor 8 and an oil temperature sensor 9 are also provided. The water temperature sensor 8 serves as a coolant temperature sensor that detects a temperature value of the radiator coolant-water (which will be referred to as a water tem-

perature value hereinafter). The oil temperature sensor 9 serves as a working-fluid temperature sensor that detects a temperature value of the working oil (which will be referred to as an oil temperature value hereinafter).

The water and oil temperature values detected by the sensors 8 and 9, respectively, are input to the controller 6. Reference character T in Fig. 1 indicates a tank.

[0021] A characteristic of water-temperature versus required-motor-speed V1 with respect to the water temperature (i.e. a cooling capability corresponding to the fan speed of the cooling fan 1) shown in Fig. 2 and a characteristic of oil-temperature versus required-motor-speed V2 with respect to the oil temperature shown in Fig. 3 are preliminarily set and stored in the controller 6. Accordingly, based on these characteristics, a required motor speed value V1 and a required motor speed value V2 with respect to the water and oil temperature values respectively detected by the water temperature sensor 8 and the oil temperature sensor 9 can be determined.

[0022] Of the two required motor speed values V1 and V2, the controller 6 selects the higher one of the values and controls the speed of the hydraulic motor 4 via the hydraulic pump 5 on the basis of the selected required motor speed value as a target value.

[0023] For example, referring to the characteristics shown in Figs. 2 and 3, in a case where the detected water and oil temperature values are both 75°, a required motor speed value with respect to the water temperature value is 800 rpm and a required motor speed value with respect to the oil temperature value is 1,180 rpm. Therefore, the higher value 1,180 rpm is selected as a target value. Accordingly, the controller 6 controls the motor speed of the hydraulic motor 4 towards the target value of 1,180 rpm.

[0024] Consequently, in contrast to the related art in which the speed control is performed by selecting between two speed modes of high speed and low speed based on a detected temperature value, the speed control according to the present invention allows for smaller speed changes in association with changes in fluid temperature (required cooling capability) since the motor speed can be changed continuously in accordance with a continuous change in the water temperature or the oil temperature.

[0025] Furthermore, since the motor speed is controlled on the basis of a target value, which is the higher one of the required motor speed values corresponding to the detected water and oil temperature values, a proper speed controlling can be achieved without over-speeding or under-speeding.

[0026] Accordingly, this reduces a drastic change in fan noise and stabilizes the operating power by reducing a drastic fluctuation of an engine consumption power for driving the cooling fan 1.

[0027] Fig. 4 is a block diagram of an engine cooling device.

[0028] Referring to Fig. 4, a cooling circuit 12 is provided with a cooling pump 10. Coolant water discharged

from the cooling pump 10 passes through an engine (water jacket) 11 and enters the radiator 2. After being cooled, the coolant water returns to the cooling pump 10.

[0029] A thermostat 13, which is a valve that is openable and closeable depending on the water temperature, is disposed adjacent to an output side of the engine 11. When the water temperature is equal to or less than a predetermined temperature value and is thus in a low temperature state, the thermostat 13 is closed such that the cooling circuit 12 is cut off. In this state, the coolant water circulates around a circulation path 14. As shown in Fig. 4, the water temperature sensor 8 is provided in the cooling circuit 12 that surrounds the circulation path 14, such that the water temperature sensor 8 detects a water temperature value in the vicinity of its position.

[0030] In contrast, if the water temperature sensor 8 is disposed within the circulation path 14, the water temperature sensor 8 will detect a water temperature value that is increased in the course of circulation. This implies that a control operation for increasing the motor speed will be implemented regardless of the fact that the radiator water temperature to be lowered may still be low, thus resulting in an unnecessary control operation.

[0031] In order to prevent this, the water temperature is detected outside of the circulation path 14 (i.e. in the cooling circuit 12) in the first embodiment, as shown in Fig. 4.

[0032] Accordingly, such an unnecessary control operation is prevented since the water temperature is detected outside of the circulation path 14.

[0033] Furthermore, since the thermostat 13 is opened at a certain water temperature value, the control operation may be performed solely in response to this certain water temperature value or higher. This means that it is not necessary to take into consideration lower water temperature values, whereby the control operation is simplified. In other words, the thermostat 13 is closed until the water temperature reaches a predetermined temperature value, and when the water temperature reaches the predetermined temperature value in the course of the circulation of the coolant water around the circulation path 14, the thermostat 13 is opened, thereby allowing the coolant water to flow into the cooling circuit 12.

[0034] Although the thermostat 13 is used as an automatic temperature-adjusting device in the first embodiment, other alternative types of automatic temperature-adjusting devices that are capable of adjusting the temperature by being opened at a predetermined water temperature value are also permissible.

[0035] A second embodiment according to the present invention will now be described with reference to Figs. 5 and 6.

[0036] The description of the second embodiment below will only include the differences from the first embodiment.

[0037] Even when the cooling fan 1 rotates at a constant rotational speed, the cooling effect may vary depending on the outside air temperature. In other words,

the higher the outside air temperature, the lower the cooling effect, whereas the lower the outside air temperature, the higher the cooling effect. Furthermore, the outside air temperature may also vary by several tens of degrees Celsius depending on location and season.

[0038] Generally, the fan function is set such that a proper cooling capability is attained even when the outside air temperature is at the highest.

[0039] Consequently, controlling the motor speed simply on the basis of the water temperature and the oil temperature may possibly cause overcooling as a result of an excess cooling capability when the system is used in an environment where the outside air temperature is low.

[0040] In order to prevent this, the second embodiment is additionally provided with an air temperature sensor 15 for detecting an outside air temperature value. Furthermore, as temperature-versus-motor-speed characteristics preliminarily set and stored in the controller 6, a solid line in Fig. 6 indicates a characteristic I corresponding to a case where the outside air temperature exceeds a predetermined temperature value, and a dashed line in Fig. 6 indicates a characteristic II corresponding to a case where the outside air temperature is equal to or lower than the predetermined temperature value. Consequently, the motor speed is controlled by selecting one of the characteristics that corresponds to the detected outside air temperature value.

[0041] Accordingly, this inhibits overcooling when the system is used in an environment where the outside air temperature is low, thereby preventing a waste of energy.

[0042] Although Fig. 6 only shows the characteristics determined by the relationship between oil temperature and motor speed, characteristics determined by the relationship between water temperature and motor speed are set in a similar manner.

[0043] Other alternative embodiments according to the present invention will be described below.

(1) As a modification example of the second embodiment, coefficients may be set and stored in accordance with outside air temperature values. In that case, a target speed value may be determined by multiplying a required motor speed value obtained from the water-temperature (or oil-temperature) versus motor-speed-characteristic by a corresponding coefficient, such that the motor speed becomes lower as the outside air temperature decreases.

(2) The hydraulic motor 4 may be an adjustable motor. In that case, the motor speed may be controlled by adjusting the motor capacity.

(3) Although the above embodiments are directed to examples in which the radiator 2 and the oil cooler 3 are cooled with a single cooling fan 1, the present invention may be similarly applied to an example in which the radiator 2, the oil cooler 3, and a heat exchanger provided in the cabin cooling device are cooled with a single cooling fan 1. In that case, a coolant temperature value may additionally be de-

tected so that the highest one of motor speed values set correspondingly with respect to the water temperature, the oil temperature, and the coolant temperature may be selected. Thus, the selected motor speed value may be used as a target value.

[0044] Alternatively, in a case where there are a large number of kinds of fluids to be cooled, a plurality of cooling fans may be provided. In that case, the control operation described above may be performed similarly for each of the hydraulic motors.

[0045] Moreover, in that case, with respect to a single hydraulic pump 5, the hydraulic motors may be connected in series or in parallel.

[0046] Although the invention has been described with reference to the preferred embodiments in the attached figures, it is noted that equivalents may be employed and substitutions made herein without departing from the scope of the invention as recited in the claims.

Claims

1. A controlling system for a cooling fan, comprising:

a fluid-pressure motor for driving the cooling fan;
a fluid-pressure pump functioning as a fluid-pressure source for the fluid-pressure motor;
temperature sensors for detecting temperature values of multiple kinds of fluids to be cooled;
and
motor-speed controlling means for controlling a rotational speed of the fluid-pressure motor,

wherein the motor-speed controlling means determines a target motor speed value by selecting a higher one of required motor speed values respectively corresponding to the fluids and controls the fluid-pressure motor so that the motor speed thereof reaches the target motor speed value, each of the required motor speed values being determined from the temperature value of the corresponding fluid detected by the corresponding temperature sensor on the basis of a characteristic preliminarily determined by a temperature-versus-motor-speed relationship for the corresponding fluid, said characteristic being set for each kind of fluid.

2. The controlling system for the cooling fan according to Claim 1, wherein said multiple kinds of fluids to be cooled includes a coolant for cooling an engine and a working fluid used for driving a fluid-pressure actuator.
3. The controlling system for the cooling fan according to Claim 2, further comprising an engine cooling device for cooling the engine, wherein the engine cooling device includes a cooling pump that discharges

the coolant and a cooling circuit provided with a coolant cooler for cooling the coolant, and wherein the coolant cools the engine by circulating around the cooling circuit.

4. The controlling system for the cooling fan according to Claim 3, wherein the temperature sensors include a coolant temperature sensor for detecting a coolant temperature value in the coolant cooler, and a working-fluid temperature sensor for detecting a temperature value of the working fluid, and wherein the motor-speed controlling means determines the target motor speed value by selecting a higher one of motor speed values determined on the basis of characteristics preliminarily determined by a coolant-temperature-versus-motor-speed relationship and by a working-fluid-temperature-versus-motor-speed relationship, the motor-speed controlling means controlling the fluid-pressure motor so that the motor speed thereof reaches the target motor speed value.

5. The controlling system for the cooling fan according to Claim 4, wherein the coolant cooler comprises a radiator, wherein the engine cooling device further includes a thermostat disposed at an intermediate position in the cooling circuit and a circulation path, wherein the cooling circuit cools the engine by allowing the coolant discharged from the cooling pump to circulate through the engine and the radiator, wherein when the coolant is in a low temperature state, the coolant output from the engine is carried back to the engine by the circulation path without passing through the radiator, and wherein the coolant temperature sensor detects a coolant temperature value in an area other than the circulation path.

6. The controlling system for the cooling fan according to Claim 1, wherein the fluid-pressure pump comprises a variable-displacement fluid-pressure pump, and wherein the motor-speed controlling means includes a pump regulator for regulating a capacity of the fluid-pressure pump, and a controller that outputs a pump-capacity command signal to the pump regulator on the basis of the temperature value of the corresponding fluid detected by the corresponding temperature sensor and on the basis of said characteristic preliminarily determined by the temperature-versus-motor-speed relationship.

7. The controlling system for the cooling fan according to Claim 1, further comprising an air temperature sensor for detecting an outside air temperature, wherein the motor-speed controlling means reduces the motor speed when the outside air temperature is lower than a predetermined temperature value.

FIG. 1

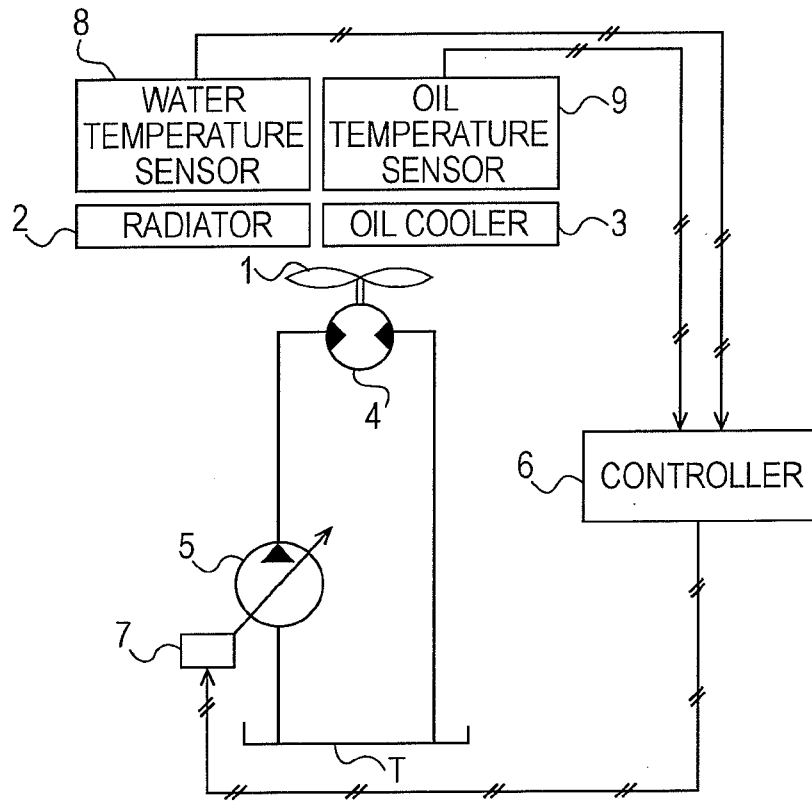


FIG. 2

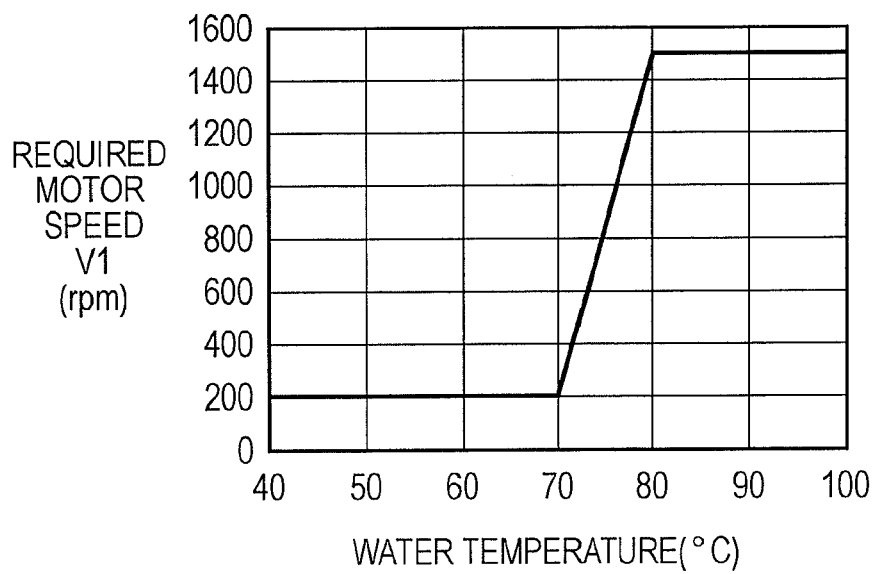


FIG. 3

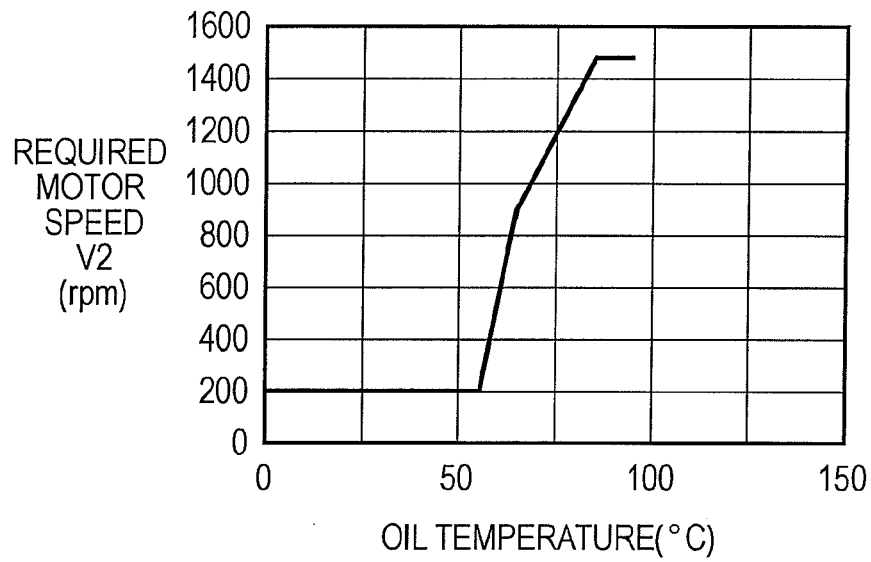


FIG. 4

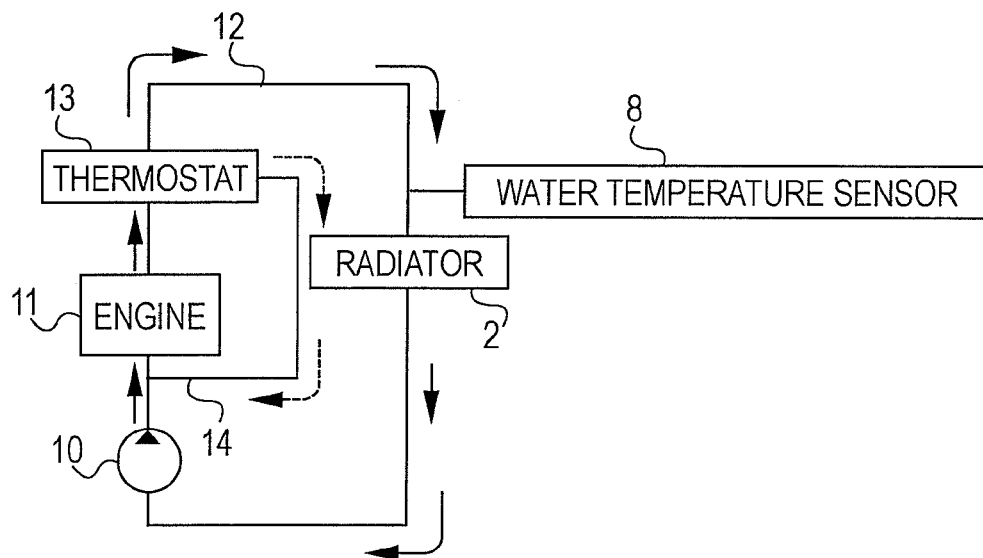


FIG. 5

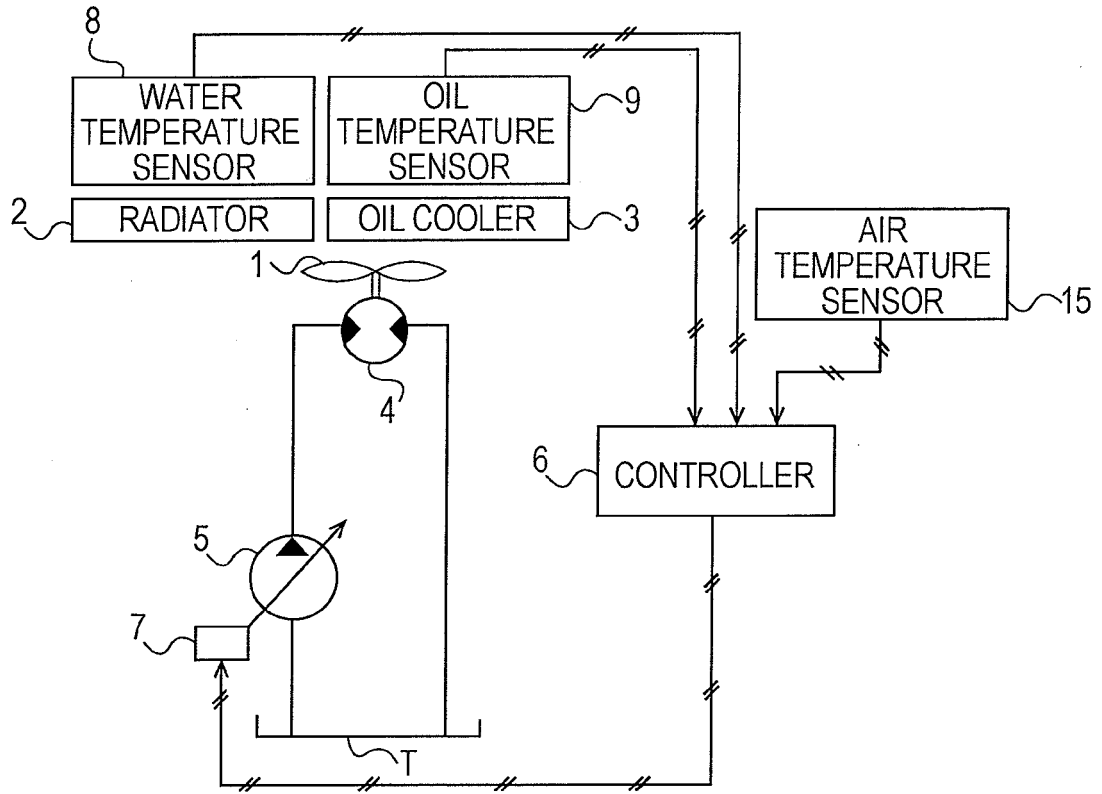
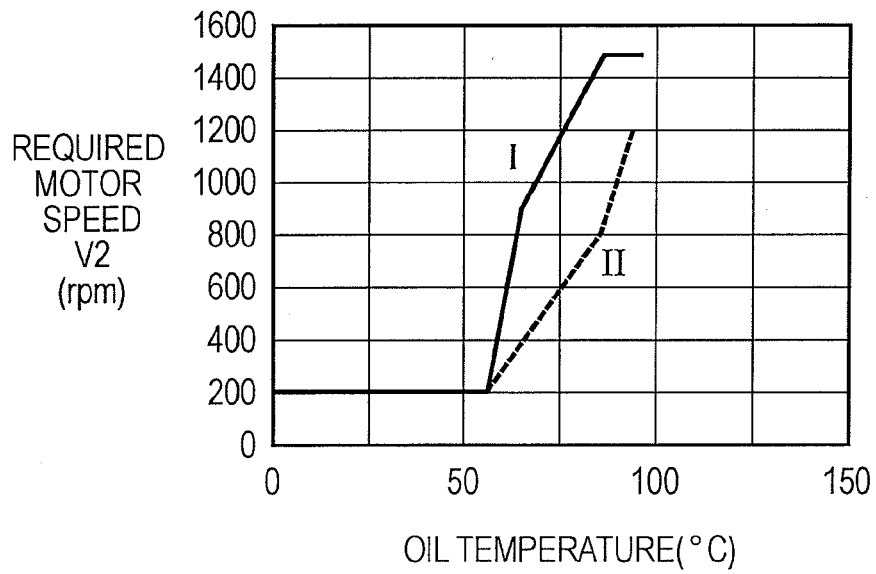


FIG. 6





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 11 6237

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Place of search Munich		Date of completion of the search 13 November 2006	Examiner Yates, John
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 06 11 6237

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