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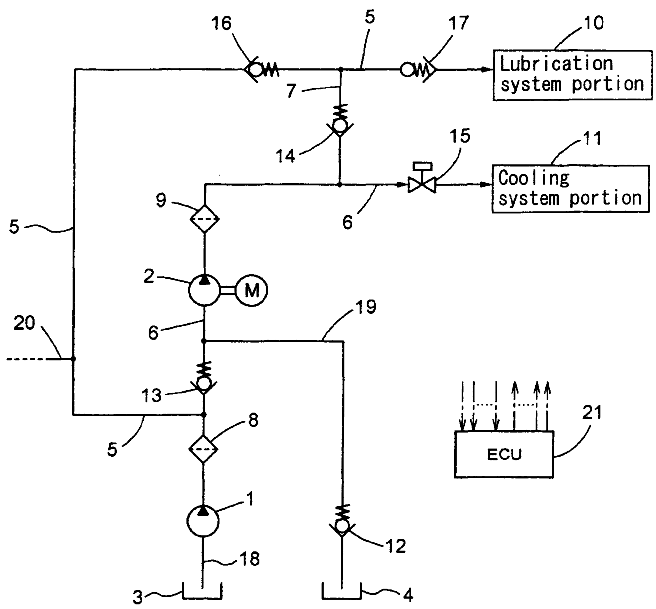
(54) **Oily supply device for engine**

(57) An oil supply device characterized by a first oil suction passage (18), a second oil suction passage (19), a first pump (1) for sucking and discharging oil from the first oil suction passage, a second pump (2) arranged in series with the first pump, the second pump for sucking and discharging oil from at least one of the first pump and the second oil suction passage, a check valve (13) for blocking oil circulation from the second pump and the second oil suction passage to the first pump, a first oil passage (5) to a lubrication system portion, a second oil passage (6) to a cooling system portion, a third oil passage (7) for establishing communication between the first oil passage and the second oil passage, and a supply volume control means (21) for varying oil supply volume to the lubrication system portion, to the cooling system portion, or to the lubrication system portion and the cooling system portion in accordance with a change in at least one of an engine oil temperature, an engine rotation speed, and an engine load.

F I G. 1



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Description

FIELD OF THE INVENTION

[0001] The present invention relates to an oil supply device for an engine. More particularly, the present invention pertains to an oil supply device for an engine, which supplies oil to lubrication system portions and cooling system portions of the engine.

BACKGROUND

[0002] A known oil supply device for an engine described in JPH04 (1992)-132414U includes a main oil pump (i.e., a first pump) and a motor driven oil pump (i.e., a second pump). According to the known oil supply device, a destination of oil from each pump is changed by appropriately switching oil passages from the both pumps on the basis of engine rotation speed. With the known oil supply device described in JPH04 (1992)-132414U, the first pump and the second pump are arranged in parallel from each other relative to a destination of oil, and oil supplied from the oil pumps is used mainly for hydraulic pressure actuation.

[0003] According to another oil supply device for an engine described in JPH10 (1998)-252434, a first pump and a second pump are arranged in series relative to a destination of oil. With this oil supply device, oil sucked from an oil reservoir is discharged by the first pump to the second pump side, and the second pump discharges the oil discharged from the first pump to the destination of the oil.

[0004] Lubrication system portions such as a cam and a cam chain, which require supply of oil for lubrication and cooling system portions such as a piston, which require supply of oil for cooling require oil supply at engine in addition to the aforementioned portions related to the hydraulic pressure actuation. However, because whether it is necessary to supply oil to the lubrication system portions and the cooling system portions is varied in accordance with temperature of oil and spattered volume of oil (amount of oil mist) and further because there is adequacy of an oil pump used for supplying oil to each portion (e.g., a pump with larger output torque is required when oil viscosity is higher), oil cannot be supplied appropriately to the lubrication system portion and the cooling system portion with known oil supply devices where oil passages are switched on the basis of only the engine rotation speed.

[0005] Further, with the construction of the oil supply device according to JPH04 (1992)-132414U, because the main oil pump and the electric oil pump are arranged in parallel to the destination of the oil, there is an drawback that the both pumps should be high output pumps when it is necessary to supply oil by high pressure relative to the destination of the oil. Further, with the construction of the oil supply device according to JPH10 (1998)-252434, the second pump cannot suck oil unless the first pump is operated, and thus the second pump cannot supply the oil to the destination of the oil. Particularly, there is a drawback that oil cannot be supplied from the second pump to the destination of the oil until the first pump sufficiently sucks oil and discharge the oil to the second pump at an engine start.

[0006] A need thus exists for an oil supply device of an engine, which appropriately supplies oil to a necessary portion.

SUMMARY OF THE INVENTION

[0007] In light of the foregoing, the present invention provides an oil supply device for an engine for supplying oil to a lubrication system portion and a cooling system portion of an engine, characterized by a first oil suction passage in communication with an oil reservoir which reserves oil, a second oil suction passage in communication with the oil reservoir, a first pump for sucking oil from the first oil suction passage by means of rotation of crankshaft of the engine and for discharging the sucked oil, a second pump arranged in series with the first pump for controlling switching On-Off operation, the second pump configured to be supplied with oil discharged from the first pump and introduced from the second oil suction passage for sucking and discharging oil from at least one of the first pump and the second oil suction passage, a check valve for blocking oil circulation from the second pump to the first pump and from the second oil suction passage to the first pump, a first oil passage diverged between the check valve and the first pump and extended to the lubrication system portion, a second oil passage extended from the second pump to the cooling system portion, a third oil passage for establishing communication between the first oil passage and the second oil passage, and a supply volume control means for varying oil supply volume to the lubrication system portion, to the cooling system portion, or to the lubrication system portion and the cooling system portion in accordance with a change in at least one of an engine oil temperature, an engine rotation speed, and an engine load.

[0008] According to the present invention, the supply volume control means can change oil supply volume from the oil pump to the lubrication system portion, to the cooling system portion, or to the lubrication system portion and the cooling system portion in accordance with operational state of the engine, for example, at least one of change of oil temperature of the engine, engine rotation speed, and engine load.

[0009] According to the present invention, the oil pump of the oil supply device includes the first pump for utilizing rotation of the crankshaft of the engine and the second pump which controls to switch operation of the oil supply device. The first pump is configured to output torque to easily discharge oil with relatively high viscosity, and can supply oil to the lubrication system portion even when oil temperature is low and oil viscosity is high. By switching On-Off of the operation of the second pump 2 in accordance with an operational state of the engine, optimum volume of oil can be supplied to the lubrication portion and to the cooling system portion in accordance with operational state of the engine. Thus, because oil supply volume can be changed freely, engine efficiency can be increased by preventing oil supply to unnecessary portion and by supplying appropriate volume of oil to necessary portions.

[0010] According to the present invention, the first valve is provided to block circulation of oil from the first oil passage to the second oil passage. By preventing supply of oil at the first oil passage to the cooling system portion, for example, it can be prevented that oil is supplied to the cooling system portion from the first pump at low oil temperature and at low engine rotation speed. As a result, for example, when the cooling portion is a piston, a piston bore is not unnecessarily cooled. Accordingly, because warm-up of the engine at the start of the engine is promoted and engine friction is declined promptly, fuel injection volume is reduced, and thus and engine with high thermal efficiency which improves mileage can be obtained.

[0011] According to the present invention, because the second pump is arranged in series with the first pump, and is arranged to suck oil discharged from the first pump, oil pressure at suction side of the second pump assumes oil pressure supplied from the first pump, and oil can be sucked with less power than power for sucking oil by the second pump alone. Accordingly, output of the second pump per se can be reduced and the second pump can be reduced in size. By arranging the second pump and the first pump in series, the second pump can output oil discharged from the first pump by further increasing the pressure with less power, and thus, it is advantageous when the second pump supplies oil to a destination of the oil such as an oil jet which requires large volume and high pressured oil.

[0012] Further, according to the present invention, because oil discharged from the first pump and oil introduced from the second oil suction passage is supplied to the second pump, the second pump alone can suck oil from the second oil suction passage even when oil is not filled up in the first pump and piping because the first pump has not sufficiently sucked oil discharged from the first pump through the first oil suction passage, for example, at immediately after the engine start.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The foregoing and additional features and characteristics of the present invention will become more apparent from the following detailed description considered with reference to the accompanying drawings, wherein:

[0014] Fig. 1 is a schematic diagram of an oil supply device according to a first embodiment of the present invention.

[0015] Fig. 2 is a partial schematic diagram of an oil supply device according to a second embodiment of the present invention.

[0016] Fig. 3 is a partial schematic diagram of an oil supply device according to a third embodiment of the present invention.

[0017] Fig. 4 is a partial schematic diagram of an oil supply device according to a fourth embodiment of the present invention.

[0018] Fig. 5 is a partial schematic diagram of an oil supply device according to a fifth embodiment of the present invention.

[0019] Fig. 6 is a partial schematic diagram of an oil supply device according to a sixth embodiment of the present invention.

[0020] Fig. 7 is a partial schematic diagram of an oil supply device according to a seventh embodiment of the present invention.

DETAILED DESCRIPTION

[0021] Embodiments of an oil supply device for an engine according to the present invention will be explained with reference to illustrations of drawing figures as follows.

[0022] As shown in Fig.1, an oil supply device for an engine according to a first embodiment of the present invention includes an oil supply circuit which includes a lubrication system portion 10 where oil for lubrication is supplied in the engine and a cooling system portion 11 where the oil for cooling is supplied. For example, the lubrication system portion 10 includes a cam shower for showering oil for lubrication to a cam, and a chain jet for jetting oil for oil to a cam chain, or the like. The cooling system portion 11, for example, includes a piston jet for jetting cooling oil to a piston.

[0023] According to this oil supply circuit, oil is supplied to the lubrication system portion 10 and the cooling system portion 11 from either a first oil reservoir 3 or a second oil reservoir 4. More particularly, the oil supply circuit includes a first pump 1 and a second pump 2 for discharging oil to the lubrication system portion 10 and the cooling system portion 11 by sucking oil from the first oil reservoir 3 and the second oil reservoir 4. As shown in Fig. 1, in order to promptly supply the oil to the second pump 2, it is preferable that the second oil reservoir 4 provided separately from the first oil reservoir 3 is arranged in the vicinity of the second pump 2. However, the first oil reservoir 3 and the second oil reservoir 4 may be provided unitarily.

[0024] According to the embodiment of the present invention, a mechanical oil pump driven by rotation of a crankshaft of an engine serves as the first pump 1. An electric oil pump whose output oil volume and ON-OFF operation are controlled by controlling actuation of a motor M serves as the second pump 2. By applying the electric oil pump as the second pump 2, for example, discharged volume of oil at the first pump 1 can be compensated by operating the second pump when the first pump is not sufficiently functioned, for example, at immediately after the engine start. Further, oil can be supplied to the lubrication portion 10 by operating the second pump 2 even before the engine start. In that case, because the engine is started at a state where the oil is sufficiently supplied to the lubrication system portion 10, friction at each portion of the engine declines, and abrasion of parts can be prevented. The second pump allows to set the first pump to have less oil discharging performance. Accordingly, the first pump, which is the mechanical oil pump, is reduced in size and friction of the engine can be declined.

[0025] The first pump 1 is connected to a first oil suction passage 18 for sucking oil from the first oil reservoir 3, and the oil sucked from the first oil reservoir 3 is discharged from the first pump 1 to flow in a first oil filter 8. The oil passes through the first oil filter 8 so that foreign materials are removed from the oil and is supplied to the lubrication system portion 10 through the first oil passage 5. When the second pump 2 is actuated, the oil which has passed through the first oil filter 8 is sucked to be introduced to a second oil passage 6, and is discharged from the second pump 2 to flow in the second oil filter 9. The oil passes through the second oil filter 9 so that foreign materials are removed from the oil and is supplied to the cooling system portion 11 or to the cooling system portion 11 and the lubrication system portion 10 through the second oil passage 6.

[0026] The second pump 2 sucks the oil which has passed through the first oil filter 8 to discharge to the second oil passage 6 when the first pump 1 is actuated. However, for example, when the oil discharge volume from the first pump 1 is not sufficiently, for example, at immediately after the engine start, it is not easy that the second pump 2 pumps oil from the first oil reservoir 3 through the first pump 1. Thus, with the construction of the embodiment of the present invention, oil is sucked from the second oil reservoir 4 which is provided separately from the first oil reservoir 3 through a second oil suction passage 19. The oil supply device according to the embodiment of the present invention includes a check valve 13 provided at the first pump 1 side relative to a connecting point between the second oil passage 6 and the second oil suction passage 19 in order to prevent oil sucked by the second oil pump 2 from flowing in reverse to the first pump 1 side. Further, the oil supply device also includes a check valve 12 on the second oil suction passage 19 in order to prevent the oil supplied from the first pump 1 to the second pump 2 from flowing in reverse to the second oil reservoir 4 side. With the construction of the embodiment of the present invention, the second pump 2 can compensate the first pump 1 at any timing.

[0027] As foregoing, because the first pump 1 and the second pump 2 are arranged in series so that the second pump 2 sucks the oil discharged from the first pump 1, hydraulic pressure at suction side of the second pump 2 assumes the hydraulic pressure which is supplied from the first pump 1, and oil can be sucked with less power than the oil is sucked only by the second pump 2. Accordingly, with the construction of the embodiment of the present invention, the second pump 2 can be reduced in size and the output from the second pump per se can be reduced. Because the second pump 2 can output the oil by further increasing oil pressure of the oil discharged from the first pump 1 with smaller power, the construction of the embodiment of the present invention is particularly advantageous for a case where the second pump 2 supplies oil to the cooling system portion 11 such as the oil jet where large volume and high pressured oil is required to be supplied.

[0028] Further, because the first oil suction passage 18 and the second oil suction passage 19 are arranged in parallel each other relative to the second pump 2, oil introduced from the first oil suction passage 18 and discharged from the first pump 1 and oil introduced from the second oil suction passage 19 is supplied to the second pump 2. Accordingly, for example, the second pump 2 alone can suck the oil from the second oil suction passage 19 provided in parallel to the first oil suction passage 18 to discharge appropriate volume of oil even when the first pump 1 is not filled up with the oil because the first pump 1 has not sufficiently sucked oil from the first oil suction passage 18, for example, at immediately after the engine start.

[0029] Instead of providing the first oil filter 8 and the second oil filter 9, oil filters may be provided at an end portion of the first oil suction passage 18 for sucking the oil from the first oil reservoir 3 and at an end portion of the second oil suction passage 19 for sucking the oil from the second oil reservoir 4.

[0030] A third oil passage 7 for establishing the communication between the first oil passage 5 extended from the first pump 1 to the lubrication system portion 10 and the second oil passage 6 extended from the second pump 2 to the cooling system portion 11 is provided between the first oil passage 5 and the second oil passage 6. A first valve 14 (e.g., a check valve) for blocking an oil circulation from the first oil passage 5 to the second oil passage 6 through the third oil passage 7 and for allowing the oil circulation from the second oil passage 6 to the first oil passage 5 through the third oil passage 7 is provided on the third oil passage 7. A second valve 16 (e.g., a check valve) for allowing oil circulation only towards the lubrication system portion 10 is provided on the first oil passage 5 at upstream side relative to a connection point between the first oil passage 5 and the third oil passage 7.

[0031] Further, a third valve 17 (e.g., stop valve) is provided on the first oil passage5 at downstream side of a connection point of the first oil passages 5 and the third oil passage 7 for allowing oil circulation when oil pressure is lower than a predetermined pressure and oil temperature is lower than a predetermined temperature and for stopping oil circulation when oil pressure is equal to or higher than a predetermined pressure and oil temperatures is equal to or lower than a predetermined temperature. A predetermined temperature and a predetermined pressure are determined in accordance with engine characteristics and parts of the engine, or the like. A fourth oil passage 20 is diverged from the first oil passage 5 at upstream side relative to the second valve 16 for supplying oil to other portions such as a crankshaft bearing portion and a camshaft bearing portion, or the like.

[0032] A fourth valve 15 which adjusts oil volume to the cooling system portion 11 is provide on the second oil passage 6 at downstream side of a connection point between the second oil passage 6 and the third oil passage 7. By controlling opening degree of the fourth valve 4, a destination and volume of oil to be supplied, the oil being discharged from the second pump 2 and circulated in the second oil passage 6 can be controlled. For example, oil which is discharged from the second pump 2 and circulated in the second oil passage 6 is supplied only to the lubrication system portion 10 through the third oil passage 7 when the fourth valve 15 is closed. When the fourth valve 15 is open, oil can be distributed to the lubrication system portion 10 and the cooling system portion 11.

[0033] The oil supply device according to the embodiment of the present invention includes an electronic control unit (ECU) 21 for detecting and outputting control signal of an engine rotation speed, a load signal of an engine, an engine oil temperature, and a water temperature of cooling water. Control signal from the ECU 21 is transmitted to the motor M and the fourth valve 15, and operation of the motor M and opening degree of the fourth valve 15 are controlled.

[0034] The ECU 21 serving as a supply volume control means conducts a supply volume changing control for changing oil supply volume from the second pump 2 to the lubrication system portion 10, to the cooling system portion 11, or to the lubrication system portion 10 and the cooling system portion 11 in accordance with changes of at least one of engine oil temperature, engine rotation speed, and engine load. Referring to Fig. 1 and Table 1, a control for opening degree of the fourth valve 15 and a control for the operation of the motor M by the ECU 21 will be explained as follows.

Table 1

	Rotation speed / Load	Oil temperature	
		Lower than predetermined value	Equal to or higher than predetermined value
Cooling system portion	Lower than predetermined value	A: No	B: No B: No Yes (electric
	Equal to or higher than predetermined value	C: No	D: Yes (electric oil pump)
Lubrication system portion	Lower than predetermined value	E: Yes	F: Yes (electric oil pump) I
	Equal to or higher than predetermined value	G: Yes	H: No

[0035] Oil supply to the cooling system portion is, first, explained with reference to Table 1. When an engine oil temperature is lower than a predetermined temperature, oil for cooling is not supplied to the cooling system portion 11 in order to avoid needless cooling of the cooling system portion 11 (i.e., corresponding to A and C in Table 1). In this case, even if the oil is supplied to the lubrication system portion 10 through the first oil passage 5 from the first pump 1, the oil is not supplied to the cooling system portion 11 from the first oil passage 5 through the third oil passage 7 because of the first valve 14 provided at the third oil passage 7.

[0036] On the other hand, when an engine oil temperature is equal to or higher than a predetermined temperature and engine rotation speed and engine load is relatively large, the cooling system portion 11 exposed to thermally severe environment is cooled (corresponding to D in Table 1). Because the viscosity of oil is low, in this case, the ECU 21 supplies oil to the cooling system portion 11 by the second pump 2 which can control operation of the oil supply device and discharged oil volume, and sets the fourth valve 15 at a predetermined opening degree. Thresholds for the engine rotation speed and engine load when the second pump 2 is operated is set in accordance with an engine characteristics and characteristics of engine parts.

[0037] When an engine oil temperature is equal to or higher than a predetermined temperature and engine rotation speed and engine load are relatively small, it is not necessary to cool the engine actively. In this case, the oil supply to the cooling system portion 11 by the second pump 2 is stopped (i.e., corresponding to B in Table 1). In this regard, it is necessary to supply oil to the lubrication system portion 10 by operating the second pump 2 even when the engine oil temperature is equal to or higher than a predetermined temperature and the engine rotation speed and engine load are at relatively low level. Thus, the ECU 21 stops supply of the oil to the cooling system portion 11 by closing the fourth valve 15.

[0038] Regarding oil supply to the lubrication system portion 10 shown in Table 1, when an engine oil temperature is lower than a predetermined temperature, it is favorable to supply oil for lubrication to the lubrication system portion 10 (i.e., corresponding to E and G in Table 1) because oil viscosity is high and spattered volume of the oil is small. In this case, the ECU 21 supplies oil to the lubrication system portion 10 by the first pump 1 which is a mechanical oil pump which enables to output larger torque and not by the second pump 2 which is an electric oil pump considering high viscosity of the oil.

[0039] When an engine oil temperature is equal to or higher than a predetermined temperature and engine rotation speed and engine load are relatively small, spattered volume of the oil assumes less whereas the oil viscosity is low. Thus, oil for lubrication is supplied to the lubrication system portion 10. In this case, because the oil viscosity is low, large torque is not necessary for discharging the oil. The ECU 21 supplies oil to the lubrication system portion 10 by the second pump 2, accordingly (i.e., corresponding to F in Table 1). In this regard, volume of oil to be supplied could be much less. Thus, for example, supply pressure of oil to the lubrication system portion 10 is set at lower pressure than supply pressure of oil to the cooling system portion 11. When an engine oil temperature is equal to or higher than a predetermined temperature and engine rotation speed and engine load are relatively large, oil viscosity assumes lower and spattered volume of oil (amount of oil mist) is increased, in this case, accordingly, it is not necessary to supply oil for lubrication to the lubrication system portion 10 (i.e., corresponding to H in Table 1).

[0040] More particularly, when an engine oil temperature is equal to or higher than a predetermined temperature, the ECU 21 serving as a supply volume control means conducts a supply volume change control for increasing oil supply to the cooling system portion 11 in accordance with an increase of engine load and engine rotation speed (i.e., corresponding to D in Table 1). When an engine oil temperature is changed to be equal to or higher than a predetermined temperature at a state where, for example, engine rotation speed is high and engine load is large, the ECU 21 operates the motor M to operate the second pump 2 (e.g., the electric oil pump) to circulate oil to the second oil passage 6. In this case, because oil temperature and oil pressure are equal to or higher than predetermined values respectively, the third valve (stop valve) 17 is closed to stop oil supply to the lubrication system portion 10. Accordingly, oil for cooling is selectively supplied to the cooling system portion 11 to cool the cooling system portion 11.

[0041] Because oil viscosity is declined at a state where an engine oil temperature is equal to or higher than a predetermined temperature, spattered volume of oil (amount of oil mist) is increased at the lubrication system portion 10, for example, when engine rotation speed and engine load are large. Thus, it is not necessary that oil for lubrication is supplied to the lubrication system portion 10 by using an oil pump. On the other hand, when an engine oil temperature is less than a predetermined temperature, the ECU 21 stops the motor M not to supply oil to the cooling system portion 11, and unnecessary energy consumption is restrained.

[0042] The ECU 21 conducts a supply volume change control for reducing oil supply volume to the lubrication system portion 10 in accordance with an increase of an engine rotation speed and engine load. More particularly, when, for example, engine rotation speed and engine load are small at a state where an engine oil temperature is equal to or higher than a predetermined temperature, the ECU 21 supplies oil to the lubrication system portion 10 by operating the second pump 2 serving as the electric oil pump. When engine rotation speed and engine load are increased at a state where an engine oil temperature is equal to or higher than a predetermined temperature, the ECU 21 conducts a control for reducing oil supply volume to the lubrication system portion 10 by closing the third valve 17. That is, when engine rotation speed and engine load are increased at a state where an engine oil temperature is equal to or higher than a predetermined temperature, spattered volume of oil (amount of oil mist) is increased. Accordingly, oil supply to the lubrication system portion 10 is stopped, and appropriate volume of oil is supplied to the cooling system portion 11. Thus, when an engine oil temperature is equal to or higher than a predetermined temperature, the ECU 21 conducts supply volume changing control for changing a destination of oil through the oil pump from the lubrication system portion 10 to the cooling system portion 11.

[0043] A second embodiment of the present invention will be explained as follows. Although, according to the first embodiment of the present invention, as shown in Fig. 1, the first valve 14 (i.e., check valve) is provided on the third oil passage 7, and the second valve 16 (i.e., check valve) is provided on the first oil passage 5 at the upstream side relative to the connection point between the first oil passage 5 and the third oil passage 7, and the third valve 17 (i.e., stop valve) is provided on the first oil passage 5 at the downstream side relative to the connection point between the first oil passage 5 and the third oil passage 7, construction of each valve can be varied. According to the second embodiment of the present invention, as shown in Fig. 2, a third valve 27 (i.e., opening and closing valve) may be provided instead of the stop valve. The ECU 21 commands to open the third valve 27 when supplying oil for lubrication to the lubrication system portion 10 by the first pump 1 and when supplying oil for lubrication to the lubrication system portion 10 by the second pump 2. Further, the ECU 21 commands to close the third valve 27 and to open the fourth valve 15 so that oil is not supplied to the lubrication system portion 10 when supplying oil for cooling only to the cooling system portion 11 by the second pump 2. Other construction of the oil supply device according to the second embodiment is common to the first embodiment, and thus explanation thereof is not repeated.

[0044] A third embodiment of the present invention will be explained with reference to Fig. 3. According to the third embodiment of the present invention, as shown in Fig. 3, a third valve 27 (i.e., a opening and closing valve) is provided on the first oil passage 5 at the upstream side of the connection point between the first oil passage 5 and the third oil passage 7 instead of the check valve, a third valve 27 (i.e., opening and closing valve) is provided on the first oil passage 5 at the downstream side of the connection point between the first oil passage 5 and the third oil passage 7 instead of the stop valve, and the first valve 14 shown in Fig. 1 is not provided. The ECU 21 commands to open the second valve 26 and the third valve 27 and to close the fourth valve 15 for supplying oil for lubrication only to the lubrication system portion 10 by the first pump 1. The ECU 21 commands to open the third valve 27 and to close the fourth valve 15 and the second valve 26 for supplying oil only to the lubrication system portion 10 by the second pump 2. Further, the ECU 21 commands to open the fourth valve 15 and to close the second valve 26 and the third valve 27 for supplying oil for cooling only to the cooling system portion 11 by the second pump 2. The ECU 21 also commands to close the second valve 26 and to open the fourth valve 15 and the third valve 27 for supplying oil for lubrication to the lubrication system portion 10 by the second pump 2 and for supplying oil for cooling to the cooling system portion 11. Accordingly, by using valves which can adjust opening degree as the second valve 26, the third valve 27 and the fourth valve 15, oil supply volume to the lubrication system portion 10 and the cooling system portion 11 can be optimally adjusted in accordance with operational state of the engine. Other construction of the oil supply device according to the third embodiment is common to the first embodiment, and thus explanation thereof is not repeated.

[0045] A fourth embodiment of the present invention will be explained as follows. According to the fourth embodiment of the present invention, the first valve 14 shown in Fig. 1 is not provided on the third oil passage 7. The ECU 21 commands to close the fourth valve 15 when supplying oil for lubrication only to the lubrication system portion 10 using either the both of the first pump 1 and the second pump 2 or either one of the first pump 1 or the second pump 2. Other construction of the oil supply device according to the fourth embodiment is common to the first embodiment, and thus explanation thereof is not repeated.

[0046] A fifth embodiment of the present invention will be explained as follows. According to the fifth embodiment of the present invention, the third valve 27 (i.e., opening and closing valve) is provided likewise the second embodiment of the present invention instead of the stop valve, and the first valve 14 is not provided on the third oil passage 7. With this construction, oil can be circulated freely between the first oil passage 5 and the second oil passage 6. Accordingly, oil volume supplied to the lubrication system portion 10 and the cooling system portion 11 is controlled by constantly adjusting the third valve 27 and the fourth valve 15. For example, the ECU 21 commands to open the third valve 27 and to close the fourth valve 15 when supplying oil for lubrication only to the lubrication system portion 10 using either the both of the first pump 1 and the second pump 2 or either one of the first pump 1 or the second pump 2. Further, when supplying oil for cooling only to the cooling system portion 11, the fourth valve 15 is opened and the third valve 27 is closed. When supplying oil to the lubrication system portion 10 and the cooling system portion 11, opening degree of the fourth valve 15 and the third valve 27 are adjusted.

[0047] A sixth embodiment of the present invention will be explained with reference to Fig. 6 as follows. According to the sixth embodiment of the present invention, plural check valves and stop valves applied in the first embodiment for supplying oil are replaced with a oil passage switching valve 30 operated by the oil pressure. With this construction, the number of parts can be reduced. Operation of the oil supply device according to the sixth embodiment of the present invention is as follows. First, when the ECU 21 stops the second pump 2, operational oil is supplied to the lubrication system portion 10 from the first pump 1. The ECU 21 operates the second pump 2 with low pressure where oil discharged at low pressure when engine rotation speed is low and an engine oil temperature is high. As a result, when the second pump 2 is operated at the low pressure, oil pressure from the second pump 2 affects an oil pressure actuation portion 33, and moves a spool valve biased by the spring 32 to the left of Fig. 6, and operation oil from the second pump 2 is supplied to the lubrication system portion 10. The ECU 21 operates the second pump 2 with high pressure when an engine rotation speed is high and an engine oil temperature is high. Accordingly, when the second pump 2 operates to discharge high pressured oil, an adjusting pressure valve 31 is closed at a state where the spool valve is moved to the left in Fig. 6 by the oil pressure from the second pump 2, and operational oil from the second pump 2 is supplied to the cooling system portion 11. Other construction of the oil supply device according to the sixth embodiment is common to the first embodiment, and thus explanation thereof is not repeated.

[0048] A seventh embodiment of the present invention will be explained with reference to Fig. 7. According to the seventh embodiment of the present invention, the oil pressure actuation portion 33 according to the sixth embodiment is replaced with a shape memory spring 43. An operation of the oil supply device according to the seventh embodiment of the present invention is as follows. First, when the ECU 21 stops the second pump 2, operational oil is supplied from the first pump 1 to the lubrication system portion 10. The ECU 21 operates the second pump 2 with low pressure for discharging oil when engine rotation speed is low and an engine oil temperature is high. As a result, the shape memory spring 43 is expanded by oil temperature of the operational oil, the spool valve biased by a spring 32 is moved to the left in Fig. 7, and operational oil from the second pump 2 is supplied to the lubrication system portion 10. The ECU 21 operates the second pump 2 with high pressure to discharge high-pressured oil when engine rotation speed is high and an engine oil temperature is high. Accordingly, when the second pump 2 is operated at high pressure, because the shape memory spring 43 is expanded at the spool valve, the adjusting pressure valve 31 is closed at a state where the spool valve is moved to the left by the oil pressure from the second pump 2, and operational oil from the second pump 2 is supplied to the cooling system portion 11.

[0049] According to the embodiment of the present invention, the supply volume control means can change oil supply volume from the oil pump to the lubrication system portion, to the cooling system portion, or to the lubrication system portion and the cooling system portion in accordance with operational state of the engine, for example, at least one of change of oil temperature of the engine, engine rotation speed, and engine load.

[0050] According to the embodiment of the present invention, the oil pump of the oil supply device includes the first pump for utilizing rotation of the crankshaft of the engine and the second pump which controls to switch operation of the oil supply device. The first pump is configured to output torque to easily discharge oil with relatively high viscosity, and can supply oil to the lubrication system portion even when oil temperature is low and oil viscosity is high. By switching On-Off of the operation of the second pump 2 in accordance with an operational state of the engine, optimum volume of oil can be supplied to the lubrication portion and to the cooling system portion in accordance with operational state of the engine. Thus, because oil supply volume can be changed freely, engine efficiency can be increased by preventing oil supply to unnecessary portion and by supplying appropriate volume of oil to necessary portions.

[0051] According to the embodiment of the present invention, the first valve is provided to block circulation of oil from the first oil passage to the second oil passage. By preventing supply of oil at the first oil passage to the cooling system portion, for example, it can be prevented that oil is supplied to the cooling system portion from the first pump at low oil temperature and at low engine rotation speed. As a result, for example, when the cooling portion is a piston, a piston bore is not unnecessarily cooled. Accordingly, because warm-up of the engine at the start of the engine is promoted and engine friction is declined promptly, fuel injection volume is reduced, and thus and engine with high thermal efficiency which improves mileage can be obtained.

[0052] According to the embodiment of the present invention, because the second pump is arranged in series with the first pump, and is arranged to suck oil discharged from the first pump, oil pressure at suction side of the second pump assumes oil pressure supplied from the first pump, and oil can be sucked with less power than power for sucking oil by the second pump alone. Accordingly, output of the second pump per se can be reduced and the second pump can be reduced in size. By arranging the second pump and the first pump in series, the second pump can output oil discharged from the first pump by further increasing the pressure with less power, and thus, it is advantageous when the second pump supplies oil to a destination of the oil such as an oil jet which requires large volume and high pressured oil.

[0053] Further, according to the embodiment of the present invention, because oil discharged from the first pump and oil introduced from the second oil suction passage is supplied to the second pump, the second pump alone can suck oil from the second oil suction passage even when oil is not filled up in the first pump and piping because the first pump has not sufficiently sucked oil discharged from the first pump through the first oil suction passage, for example, at immediately after the engine start.

[0054] According to the embodiment of the present invention, when oil is supplied to the lubrication system portion from the second pump, reverse circulation of oil, which has circulated into the first oil passage from the second oil passage through the third oil passage, to the first pump side is blocked. Thus, oil can be securely supplied to the lubrication system portion. Further, when switching ON-OFF of the operation of the second pump, oil supply to the lubrication system portion by the first pump is not interrupted and oil is supplied at engine smoothly.

[0055] When engine rotation speed is increased, volume of oil spattered inside a crankcase is increased. With the foregoing state, for example, lubricating the lubrication system portion such as the cam shower and the chain jet can be sufficiently completed by spattering oil. Thus, further oil supply, in this case, from the pump to the lubrication system portion becomes operational resistance of parts of the engine. With the construction of the embodiment of the present invention, accordingly, the third valve configured to close when pressure of oil discharged from the first pump or the second pump is increased to be equal to or higher than a predetermined pressure is provided at downstream side relative to the connection point between the first oil passage and the third oil passage. Thus, when volume of the oil spattered inside the crankcase is increased because of increase of engine rotation speed, the third valve is closed, further oil supply to the lubrication system portion is stopped, and a decline of the engine efficiency can be effectively prevented.

[0056] According to the embodiment of the present invention, by controlling opening degree of the fourth valve, volume of oil to be supplied and a destination of oil to be supplied which has discharged from the second pump and circulated in the second oil passage can be controlled. For example, oil discharged from the second pump and circulated in the second oil passage is supplied only to the lubrication system portion through the third oil passage when the fourth valve is closed. When the fourth valve is open, oil discharged from the second pump and circulated in the second oil passage is distributed to the lubrication system portion and the cooling system portion. Accordingly, by controlling opening degree of the fourth valve, oil volume supplied to the lubrication system portion and oil volume supplied to the cooling system portion can be controlled.

[0057] In this case, the ECU 21 (i.e., supply volume control means) may control an opening degree of the fourth valve and opening and closing of the second and the third valves or may control an opening degree of the fourth valve and opening and closing of the third valve.

It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

Claims

1. An oil supply device for an engine for supplying oil to a lubrication system portion (10) and a cooling system portion (11) of an engine, **characterized by**
a first oil suction passage (18) in communication with an oil reservoir (3) which reserves oil;
a second oil suction passage (19) in communication with the oil reservoir;
a first pump (1) for sucking oil from the first oil suction passage by means of rotation of crankshaft of the engine and for discharging the sucked oil;
a second pump (2) arranged in series with the first pump for controlling switching On-Off operation, the second pump configured to be supplied with oil discharged from the first pump and introduced from the second oil suction passage for sucking and discharging oil from at least one of the first pump and the second oil suction passage;
a check valve (13) for blocking oil circulation from the second pump to the first pump and from the second oil suction passage to the first pump;
a first oil passage (5) diverged between the check valve and the first pump and extended to the lubrication system portion;
a second oil passage (6) extended from the second pump to the cooling system portion;
a third oil passage (7) for establishing communication between the first oil passage and the second oil passage; and
a supply volume control means (21) for varying oil supply volume to the lubrication system portion, to the cooling system portion, or to the lubrication system portion and the cooling system portion in accordance with a change in at least one of an engine oil temperature, an engine rotation speed, and an engine load.

2. The oil supply device according to Claim 1, wherein the supply volume control means varies the oil supply volume to the lubrication system portion, to the cooling system portion, or to the lubrication system portion and the cooling system portion by controlling switching On-Off operation of the second pump.

3. The oil supply device according to Claim 2, further comprising:

a first valve (14) provided on the third oil passage for blocking oil circulation from the first oil passage to the second oil passage.

4. The oil supply device according to Claim 2, further comprising:

a second valve (16) provided on the first oil passage at upstream side relative to a connection point between the first oil passage and the third oil passage.

5. The oil supply device according to Claim 4, wherein the second valve is one of a check valve for allowing oil circulation only in a direction from the first pump to the lubrication system portion and an opening and closing valve for blocking oil circulation in the first oil passage.

6. The oil supply device according to any one of Claims 1-5, further comprising:

a third valve (17) provided on the first oil passage at downstream side relative to the connection point between the first oil passage and the third oil passage.

7. The oil supply device according to Claim 6, wherein the third valve is opened at a predetermined pressure.

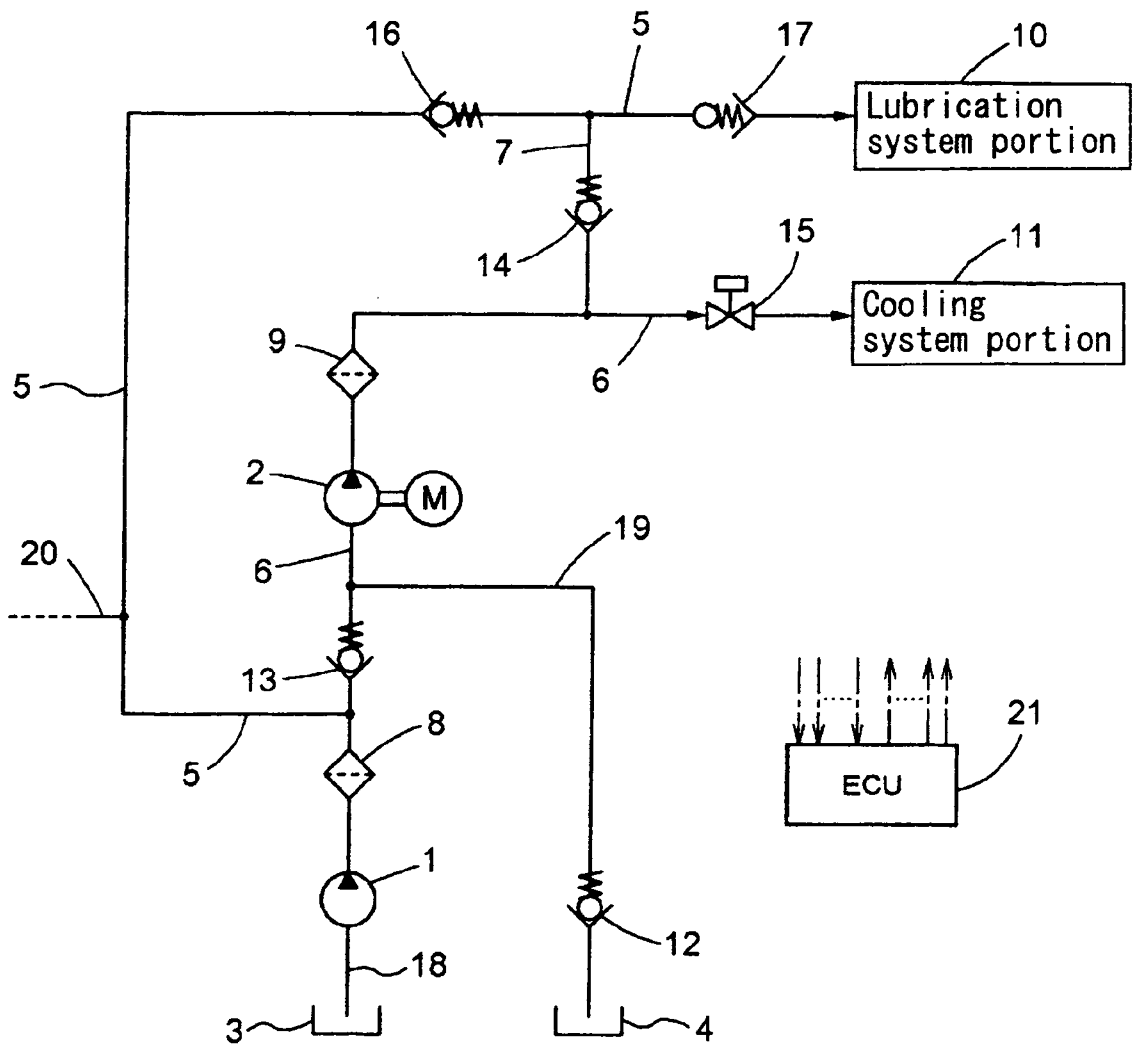
8. The oil supply device according to any one of Claims 1-7, further comprising:

a fourth valve (15) provided on the second oil passage at downstream side relative to a connection point between the second oil passage and the third oil passage.

9. The oil supply device according to Claim 8, wherein the fourth valve is a flow adjusting valve for adjusting volume of flown oil.

10. The oil supply device according to Claim 8, wherein the supply volume control means controls an opening degree of the fourth valve.

FIG. 1


16
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17
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Lubrication system portion
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Cooling system portion
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FIG. 2

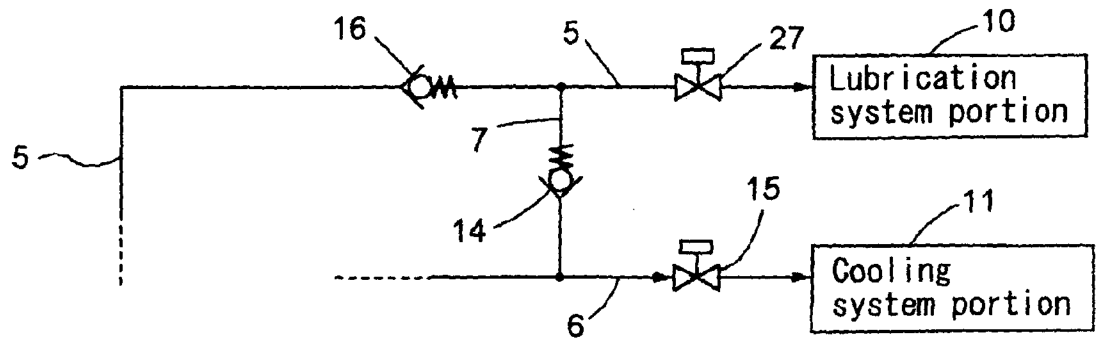


FIG. 3

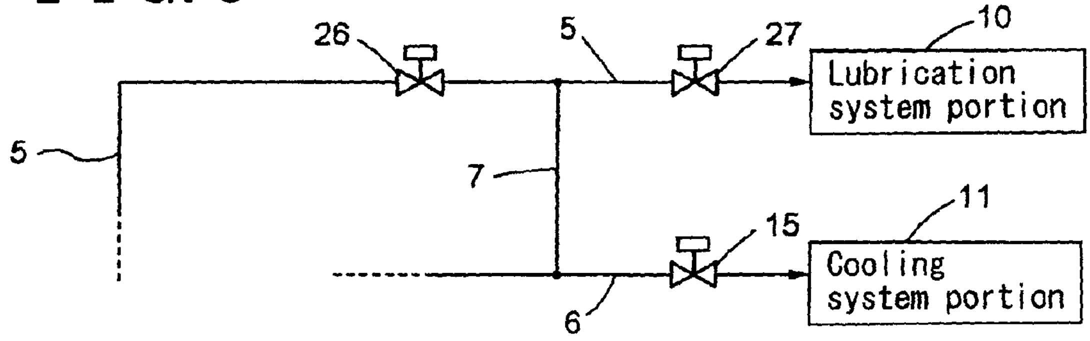


FIG. 4

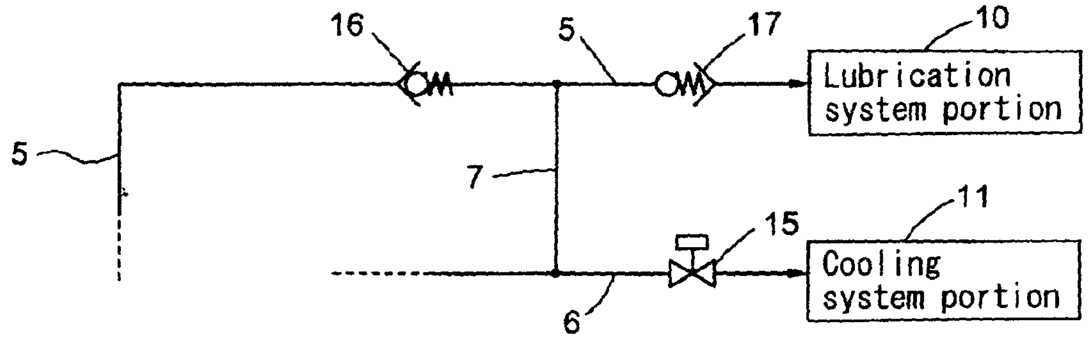


FIG. 5

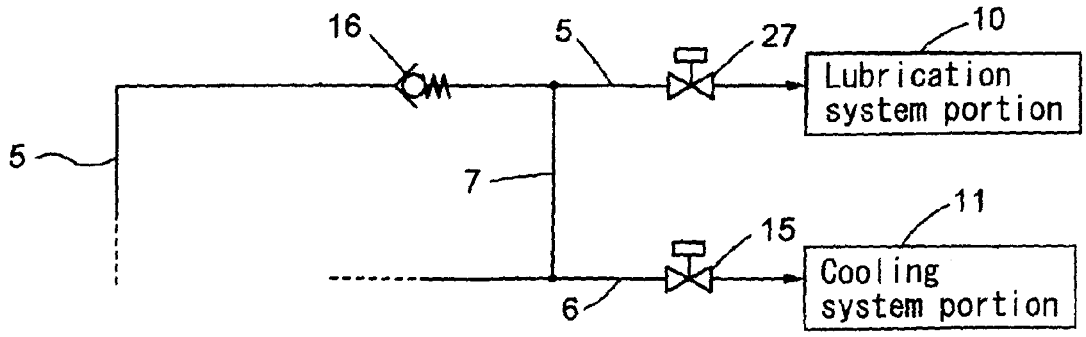
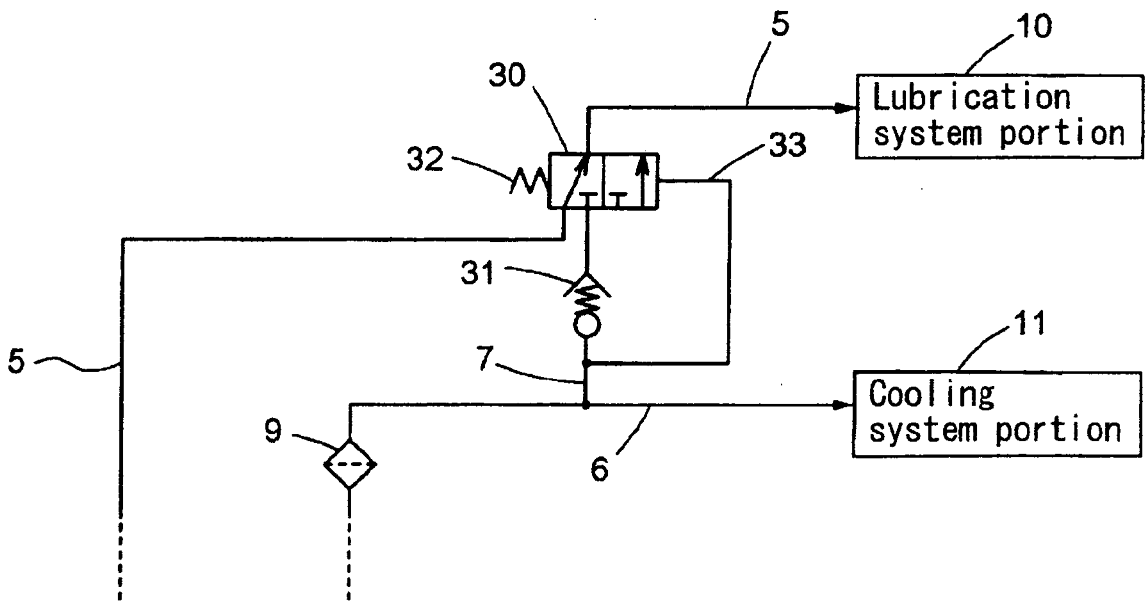


FIG. 6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Lubrication system portion
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Cooling system portion
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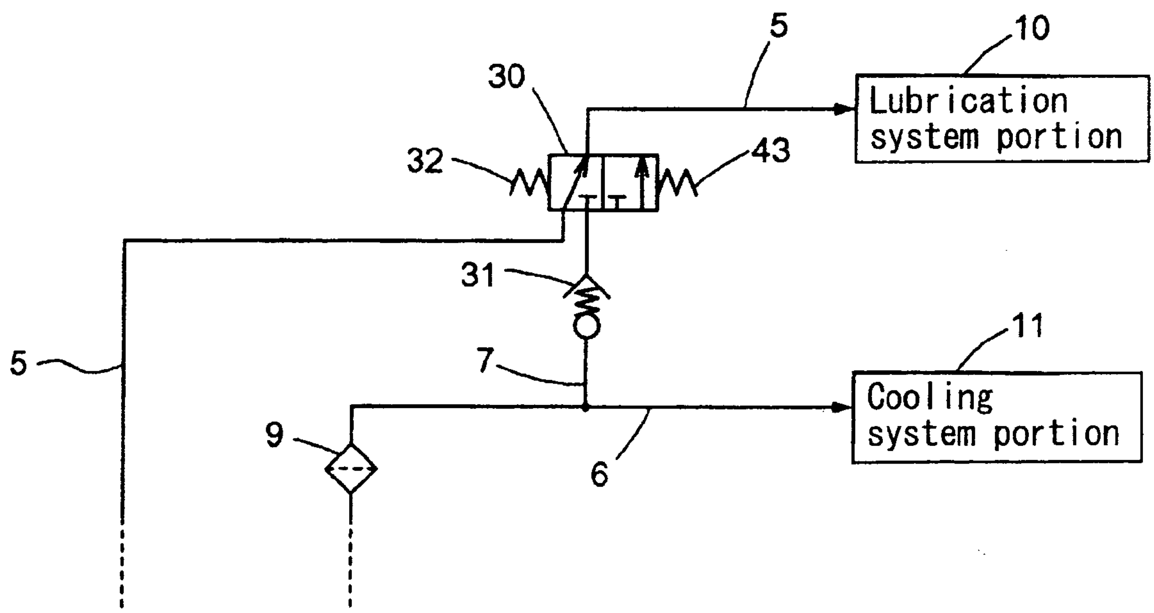
FIG. 7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Cooling system portion
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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 05 02 0471

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A	WO 2004/076825 A (AISIN SEIKI KABUSHIKI KAISHA; FUTAMURA, KAZUMASA; SHIRAI, MAKOTO; FUJI) 10 September 2004 (2004-09-10) * figure 11 * * abstract *	1	
L	-& EP 1 598 531 A (AISIN SEIKI KABUSHIKI KAISHA) 23 November 2005 (2005-11-23) * paragraphs [0055] - [0059], [0089] - [0091], [0101], [0102] * * figure 11 * -----		

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F01M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	13 December 2005	Mallo Lopez, M

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13-12-2005

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