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(54) Internal combustion engine with cylinder lubricating system

(57) An internal combustion engine having a plurality of lubricators (12a,12b,12c...12n) attached to one cylinder (11) for supplying lube oil in the common lube oil feeding section (15) to the inner surface of the cylinder (11), wherein are provided a plurality of electromagnetic valves (17a,17b,17c...17n) for opening or closing oil passages (16a,16b...16n) connecting to the lubricators independently; lube oil supply pressure detectors (21) for detecting the lube oil supply pressure of each of the lubricators; and a controller (19) which controls the timing and period of opening of each of said electromagnetic valves in accordance with loads and rotation speeds of the engine, compares the detected lube oil supply pressure of each of the lubricators with a permissible value of lube oil supply pressure, and judges that abnormality has occurred in lube oil supply when the detected lube oil supply pressure exceeds the permissible value.

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Description

BACKGROUND OF THE INVENTION

Field of the invention

[0001] The present invention relates to an internal combustion engine with a cylinder lubricating system applied to a large marine diesel engine, etc., lubricating oil pressure-fed by a lubricating oil pump being accommodated in a common lube oil feeding section, the lubricating oil in the common lube oil feeding section being supplied to a plurality of lubricators attached to engine cylinders to be supplied to the inner surfaces of the cylinders by the system.

Description of the Related Art

[0002] In large marine diesel engines, mechanical cylinder lubricating system are widely used, in which, as disclosed for example in JP59-175619U, a plurality of lubricators are arranged along the circumferential direction of a cylinder, and lubricating oil pressure-fed by an oil pump of plunger type driven by the rotation of the crankshaft is supplied to the inner surface of the cylinder by said lubricators.

[0003] In the lubricating system, a plurality of lubricators (injectors) are arranged along the circumferential direction of the cylinder, the plunger of a plunger type oil pump is reciprocated by the rotation of the cam formed on a camshaft driven by the crankshaft of the engine, and lubricating oil is supplied through oil pipes connecting the oil pump to the lubricators at timing in syntonization with the rotation of the crankshaft to be supplied to the inner surface of the cylinder by the lubricators. With the mechanical cylinder lubricating system disclosed in said patent literature 1, lubricating oil is supplied to the inner surface of the cylinder from the lubricators at timing in syntonization with engine rotation, so that the lube oil feed timing and the characteristic of lube oil feed quantity are determined at the stage of engine assembling, the timing and also quantity of oil supplied are difficult to be adjusted, and it is impossible to control the lubrication timing and the quantity of lubricating oil supplied by each of a plurality of lubricators. There is no disclosure in said patent literature 1 concerning detection of occurrence of abnormality in supplying lube oil from the lubricators to the cylinder and means to cope with the abnormality.

SUMMARY OF THE INVENTION

[0004] The present invention was made in light of the problems in the prior art as mentioned above. The object of the invention is to provide an internal combustion engine provided with a cylinder lubricating system, in which it is possible to supply necessary amount of lubricating oil at necessary timing to each of lubricators or to each of positions to be supplied with lubricating oil in accordance with the rotation speed or load of the engine and to detect the occurrence of abnormality in supplying lube oil from the lubricators quickly and accurately, whereby stable supply of lube oil can be maintained all over the operating range of the engine through taking effective measures to meet the situation of the abnormality.

[0005] To attain the object, the present invention proposes an internal combustion engine provided with a lubricating system in which lubricating oil pressure-fed by a lubricating oil pump is accommodated in a common lube oil feeding section, the lubricating oil contained in said common lube oil feeding section is supplied to a plurality of lubricators (injectors) attached to the cylinders of the engine through oil passages connecting said common lube oil feeding section to each of said lubricators respectively and injected to the inner surfaces of cylinders of the engine by said lubricators, wherein are provided a plurality of electromagnetic valves for opening or closing each of said oil passages independently; lube oil supply pressure detectors for detecting pressures of lube oil supplied to the cylinders; and a controller which controls the timing and period of opening of each of said electromagnetic valves in accordance with the load and rotation speed of the engine, compares the detected lube oil supply pressure of each of the lubricators with a permissible value of lube oil supply pressure, and judges that abnormality has occurred in lube oil supply when the detected lube oil supply pressure exceeds said permissible value.

[0006] In the invention, it is preferable specifically that said controller judges that there has occurred malfunction in lube oil supply when the pressure difference between the peak pressure and base pressure of lube oil supply based on the pressure detected by and inputted from said lube oil supply pressure detector is equal or smaller than a permissible pressure difference determined beforehand.

[0007] According to the invention, the timing and period of opening of the electromagnetic valves for opening/closing the oil passages connecting the common lube oil feeding section to a plurality of the lubricators for supplying lube oil to the inner surfaces of the cylinders are controlled respectively in accordance with loads or rotation speeds of the engine, and it is judged that malfunction has occurred in lube oil supply when the detected lube oil supply pressure exceeds said permissible pressure determined beforehand, particularly when the pressure difference between the peak pressure and base pressure of lube oil supply is equal or smaller than a permissible pressure difference determined beforehand.

[0008] Therefore, whether abnormality has occurred in lube oil supply due to shortage in valve lift of the electromagnetic valve or other factors can be judged quantitatively for each of the electromagnetic valves.

[0009] Accordingly, abnormality in lube oil supply can

be detected for each of the electromagnetic valves and lubricators, fast recovery from the abnormality is possible, and occurrence of wear or sticking in the inner surface of cylinder due to deteriorated lubrication as a result of the abnormality of lube oil supply action can be positively evaded.

[0010] In the invention, it is preferable that said controller determines said permissible pressure difference on the basis of the timing and period of the electromagnetic valve and the pressure in the common lube oil feeding section.

[0011] In the invention, it is preferable that the controller judges that malfunction has occurred in the electromagnetic valve when the period of time during which the detected lube oil supply pressure exceeds a predetermined threshold value is longer than a permissible period of time.

[0012] In the invention, it is preferable that said controller judges that malfunction has occurred in the lubricator when the pressure difference between the peak pressure of the detected lube oil supply pressure and the pressure in the common lube oil feeding section is equal or larger than a permissible pressure difference determined beforehand.

[0013] By composing like this, whether there has occurred malfunction in any of the electromagnetic valves and lubricators can be judged by a simple means to compare the detected lube oil supply pressure difference with the permissible pressure difference.

[0014] The present invention proposes an internal combustion engine provided with a lubricating system in which lubricating oil pressure-fed by a lubricating oil pump is accommodated in a common lube oil feeding section, the lubricating oil contained in said common lube oil feeding section is supplied to a plurality of lubricators(injectors) attached to the cylinders of the engine through oil passages connecting said common lube oil feeding section to each of said lubricators respectively and injected to the inner surfaces of cylinders of the engine by said lubricators, wherein are provided a plurality of electromagnetic valves for opening/closing oil passages connecting to a plurality of said lubricators respectively, oil pressure cutoff valves attached to oil passages connecting the electromagnetic valves to the common lube oil feeding section for shutting off said oil passages, and an oil cutoff valve actuating means for allowing said oil cutoff valve actuating means to actuate when malfunction occurs in lube oil supply operation performed by the lubricators and controlled by the electromagnetic valves.

[0015] According to the invention, when malfunction occurs in the lubricators or electromagnetic valves for opening/closing the oil passages connecting to the lubricators, the oil passage connecting to the malfunctioning lubricator or electromagnetic valve is shutoff by the oil pressure cutoff valve connecting to the malfunctioning lubricator or electromagnetic valve, and the malfunctioning part is repaired. Therefore, when malfunction occurs in one of the lubricators or electromagnetic valves, lube oil supply to the malfunctioning lubricator or electromagnetic valve can be shutoff by actuating the oil pressure cutoff valve connecting to the malfunctioning lubricator or electromagnetic valve while continuing the operation of the engine. So, malfunctioning part can be repaired and restored without halting engine operation.

[0016] In the invention, it is preferable that a controller is provided which allows the lube oil supply by the lubricators to be restored upon receiving a signal to release the actuation of the oil pressure cutoff valve when it is inputted to the controller.

[0017] By composing like this, when the malfunctioning part of the lubricator or electromagnetic valve is repaired, normal function is recovered, and the actuation of the oil pressure cutoff valve is released, the lubricator and electromagnetic valve are allowed to come back automatically to normal operation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

FIG.1 is an overall connecting diagram of the first embodiment of the cylinder lubricating system of an internal combustion engine according to the present invention.

FIG.2 is an overall connecting diagram of the second embodiment of the cylinder lubricating system.

FIG.3 is a connecting diagram of the third embodiment corresponding to FIG.2.

FIG.4 is a control block diagram of the first to third embodiment.

FIG . 5 is a schematic representation of the electromagnetic valve used in the first to third embodiment.

FIG.6 is a graph for explaining the operation of the first and second embodiments.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] A preferred embodiment of the present invention will now be detailed with reference to the accompanying drawings. It is intended, however, that unless particularly specified, dimensions, materials, relative positions and so forth of the constituent parts in the embodiments shall be interpreted as illustrative only not as limitative of the scope of the present invention.

[0020] FIG.1 is an overall connecting diagram of the first embodiment of the cylinder lubricating system of an internal combustion engine according to the present invention, and FIG. 2 is anoverall connecting diagram of the second embodiment of the cylinder lubricating system. FIG.3 is a connecting diagram of the third embodiment corresponding to FIG.2. FIG.4 is a control block diagram of the first to third embodiment. FIG.5 is a schematic representation of the electromagnetic valve used in the first to third embodiment. FIG.6 is a graph for ex-

plaining the operation of the first and second embodiments.

[0021] In an example of the first embodiment shown in FIG.1, electromagnetic valves are provided for each of lubricators. In FIG. 1, reference numeral 11 are cylinder liners (cylinders) and two cylinders are shown in the drawing. Reference numerals 12a, 12b, 12c, · · · , 12n (omitted in the drawing) are lubricators for feeding lube oil to the inner surface of each cylinder 11. The plural lubricators 12a, 12b, 12c, · · · , 12n are located along the periphery of each cylinder 11 preferably spaced equidistantly.

[0022] Reference numeral 14 is a lube oil pump, 15 is a common lube oil feeding section in which lube oil pressure-fed by the lube oil pump 14 is accumulated. Reference numerals 16a, 16b, 16c, 16d, · · · , 16n are oil passages connecting the common lube oil feeding section 15 to the lubricators 12a, 12b, 12c, · · · , 12n of each cylinder.

[0023] Reference numerals 17a, 17b, 17c, 17d, 17e, · · · , 17n are electromagnetic valves provided at each of the oil passages 16a, 16b, 16c, 16d, · · · , 16n respectively for opening /closing each of the passages 16a, 16b, 16c, 16d, · · ·, 16n.

[0024] The timing and period of opening of each of the electromagnetic valves 17a, 17b, 17c, 17d, 17e, · · ·, 17n is controlled independently by the controller 19.

[0025] Reference numerals 18a, 18b, 18c, 18d, 18e, · · · , 18n are lube oil flow limiters, each of which are located upstream of each of the electromagnetic valves 17a, 17b, 17c, 17d, 17e, · · · , 17n which are provided to each of the oil passages 16a, 16b, 16c, 16d, · · ·, 16n for opening /closing each of the oil passages 16a, 16b, 16c, 16d, · · ·, 16n.

[0026] In FIG.5 is shown the structure of the electromagnetic valve 17 (17a, 17b, 17c, 17d, 17e, · · · , 17n) schematically. In the drawing, reference numeral 172 is a valve case, 173 is a valve seat, 171 is a valve body, 174 is an armature fixed on the valve body 171, 175 is a solenoid, 176 is a valve room. In an electromagnetic valve like this, when the solenoid 175 is energized, the armature 174 is pulled up and the valve body 171 is lifted up by a distance L, and the lube oil supplied to the valve room 176 is sent out to an outlet passage 178. In the drawing, Ga is the air gap between the undersurface of the solenoid 175 and the upper surface of the armature 174 when said lift L is at its maximum.

[0027] In the cylinder lubricating system shown in FIG.1, when the lube oil pressure-fedby the lube oil pump 14 is accumulated in the common lube oil feeding section 15 and each of the oil passages 16a, 16b, 16c, 16d, · · · 16n is opened by the actuation of each of the electromagnetic valves 17a, 17b, 17c, 17d, 17e, · · · , 17n each of which are controlled independently by the controller 19, the lube oil accumulated in the common lube oil feeding section 15 is supplied to each of the lubricators 12a, 12b, 12c, · · · , 12n through each of the oil passages 16a, 16b, 16c, 16d, · · · 16n to be injected to the inner surface of the cylinder liner 11.

[0028] Reference numeral 1 is an engine rotation speed detector for detecting the rotation speed of the engine, 2 is a fuel injection quantity sensor for detecting the quantity of fuel injected into the cylinder, 3 is a crank angle sensor for detecting crank angles of engine, i.e. rotation positions of the crankshaft of engine. Reference numeral 4 is a load detecting means by which engine load(output) is calculated from the engine rotation speed detected by said engine rotation speed detector 1 and the fuel injection quantity detected by said fuel injection quantity sensor 2. Reference numeral 5 is a pressure sensor for detecting the pressure in the common lube oil feeding section.

[0029] Reference numeral 21 are oil pressure sensors for detecting the oil pressure of eachof said lubricators 12a, 12b, 12c, · · · , 12n. Each of the pressure sensors 21 is attached to each of the oil passages 16a, 16b, 16c, 16d, · · · 16n and detects the lube oil supply pressure of each of the lubricators 12a, 12b, 12c, · · ·, 12n. It may be suitable that each of the pressure sensors 21 is provided not for eachof the oil passages 16a, 16b, 16c, 16d, · · · , 16n but one pressure sensor is provided for a plurality of the oil passages.

[0030] The engine rotation speed detected by the engine rotation speed detector 1, the engine load detected (calculated) by the load detecting means 4, the crank angle detected by the crank angle sensor 3, the oil pressures of the lubricators 12a, 12b, 12c, · · · , 12n detected by the oil pressure sensors 21, and the oil pressure in the common lube oil feeding section detected by the pressure sensor 5 are inputted to a judging part 191(see FIG.4) of the controller 19, the judging part 191 being for judging the state of lube oil supply action.

[0031] In the second embodiment shown in FIG.2, a plurality of said lubricators 12 are attached to one cylinder as shown by 12a, 12b, 12c, 12d, 12e, · · · , 12n, and oil passages connecting to the lubricators 12 consist of main oil passages 161, 162, 163, and 164, and branched oil passages 16a, 16b, 16c, 16d, 16e, · · ·, 16n (these being corresponding to the oil passages in the first embodiment) branching from the main oil passages 161, 162, 163, and 164 to be connected to each of the lubricators 12a, 12b, 12c, 12d, 12e, · · · ,12n. Electromagnetic valves 17 (17A, 17B) are provided to the main oil passages 161, 162, 163, and 164 respectively so that one electromagnetic valve presides lube oil supply to a plurality of lubricators(for example, the electromagnetic valve 17A presides lube oil supply to the lubricators 12a, 12b, and 12c) in order to reduce the number of the electromagnetic valves 17.

[0032] Reference numeral 18A is a lube oil flow limiter provided in the upstream of the electromagnetic valves 17A, and 18B is a lube oil flow limiter provided in the upstream of the electromagnetic valves 17B.

[0033] Reference numeral 21a, 21b, 21c, 21d, 21e, · · · 21n are pressure sensors for detecting lube oil supply pressures of the lubricators 12a, 12b, 12c, · · ·, 12n.

These pressure sensors 21a, 21b, 21c, 21d, 21e, · · · 21n are attached to the oil passages 16a, 16b, 16c, 16d, · · · , 16n respectively to detect the lube oil supply pressure of each of the lubricators 12a, 12b, 12c, · · ·, 12n respectively. The pressure sensors 21 may be attached to the main oil passages 161, 162, 163, and 164 as shown by dotted leader lines in FIG.2.

[0034] The lube oil supply pressures detected by the pressure sensors 21a, 21b, 21c, 21d, 21e, · · · 21n are inputted to the state of lube oil supply action judging part 191 (see FIG. 4) of the controller 19.

[0035] The configuration other than that mentioned above is similar to that of the first embodiment shown in FIG.1 and the same constituent members are indicated by the same reference numbers.

[0036] By the way, detectors and sensors shown in FIG.1 are not shown in FIG.2.

[0037] In the third embodiment shown in FIG.3, a plurality of said lubricators 12 are attached to one cylinder as shown by 12a, 12b, 12c, 12d, 12e, · · · , 12n, and oil passages connecting to the lubricators 12 consist of main oil passages 161, 162, 163, and 164, and branched oil passages 16a, 16b, 16c, 16d, 16e, · · ·, 16n (these being corresponding to the oil passages in the first embodiment) branching from the main oil passages 161, 162, 163, and 164 to be connected to each of the lubricators 12a, 12b, 12c, 12d, 12e, · · · ,12n. Electromagnetic valves 17 (17A, 17B, 17C, and 17D) are provided to the main oil passages 161, 162, 163, and 164 respectively so that one electromagnetic valve presides lube oil supply to a plurality of lubricators (for example, the electromagnetic valve 17A presides lube oil supply to the lubricators 12a, 12b, and 12c).

[0038] Reference numeral 18 is a lube oil flow limiter provided in the upstream of the electromagnetic valves 17A, 18B is a lube oil flow limiter provided in the upstream of the electromagnetic valves 17B, 18C is a lube oil flow limiter provided in the upstream of the electromagnetic valves 17C, and 18D is a lube oil flow limiter provided in the upstream of the electromagnetic valves 17D.

[0039] The configuration mentioned above is similar to that of the second embodiment shown in FIG.2.

[0040] In the third embodiment, oil pressure cutoff valves 24A, 24B, 24C, and 24D are attached to the main oil passages 161, 162, 163, and 164 for shutting off the communication of the oil passages 16a, 16b, 16c, 16d, 16e, · · · , 16n to the lubricators 12a, 12b, 12c, 12d, 12e, · · · , 12n so that the main oil passages161, 162, 163, and164 canbe shutoff throughactuating the cutoff valves 24A, 24B, 24C, and 24D by control signals sent from the controller or through manual operation.

[0041] The configuration other than that mentioned above is similar to that of the second embodiment shown in FIG.2, and the same constituent members are indicated by the same reference numbers.

[0042] Next, the operation of the first to third embodiment will be explained referring to FIG. 4 showing a control block diagram and FIG. 1 ~ FIG.3.

[0043] In FIG.4, reference numeral 192 is a reference setting part for setting the reference for lube oil supply action, in which permissible pressure differences ΔP are set in correspondence with engine rotation speeds or engine loads, ΔP being permissible pressure differences between peak values of fluctuating lube oil supply pressures and a base lube oil supply pressure, malfunction in the lube oil supply lines including the lubricators 12a, 12b, 12c, 12d, 12e, · · ·, 12n and the electromagnetic valves 17(the electromagnetic valves 17a, 17b, 17c, 17d, 17e, · · ·, 17n in the first embodiment shown in FIG. 1, and the electromagnetic valves 17A, 17B, 17C, and 17D in the second and third embodiment) being judged on the basis of the pressure differences.

[0044] As shown in FIG.6, the pressure difference ΔP is defined as the difference of pressure between the peak value Pp of a fluctuating lube oil supply pressure and a base lube oil supply pressure Pb.

[0045] As the permissible pressure difference ΔP, there are set minimum permissible pressure difference P_{min} and maximum permissible pressure difference P_{max} in accordance with the opening period of electromagnetic valve and the oil pressure in the common lube oil feeding section, that is, with loads and rotation speeds of the engine and the the common lube oil feeding section.

[0046] The state of lube oil supply action judging part 191 compares the pressure difference $\Delta P1$ (detected pressure difference) calculated from the detected fluctuating lube oil supply pressure inputted from each of the pressure sensors 21 (21a, 21b, 21c, 21d, 21e, · · · 21n) and said minimum permissible pressure difference ΔP_{min}, judges that, when the detected pressure difference $\Delta P1$ is equal or smaller than the minimum permissible pressure difference ΔP_{min} (when $\Delta P1 \leqq P_{low}$) , malfunction has occurred in the lube oil supply line to which the concerned pressure sensor 21 is attached(for example, when the detected pressure difference calculated for the pressure sensor 21a is equal or smaller than the minimum permissible pressure difference ΔP_{min}, it is judged that malfunction has occurred to the lube oil supply line connecting to the lubricator 12a).

[0047] The judgment is sent to an electromagnetic valve control part 193 and to an oil pressure cutoff valve control part 194. The oil pressure cutoff valve control part 194 allows the oil pressure cutoff valve 24 of the concerned lube oil supply line to be shutoff (for example, the oil pressure cutoff valve 24A is shutoff).

[0048] With the embodiment, the timing and period of opening of each of the electromagnetic valves 17 (the electromagnetic valves17a, 17b, 17c,17d,17e, · · · , 17n or the electromagnetic valves 17A, 17B, 17C, and 17D) for controlling lube oil supply to each of the lubricators 12a, 12b, 12c, 12d, 12e, · · · ,12n are controlled in correspondence with engine loads and rotation speeds, and malfunction in supplying lube oil judged to have oc-

curred when the pressure difference ΔP1 (detected pressure difference) between the peak pressure of the fluctuating lube oil supply pressure detected by the oil pressure sensor 21 (21a, 21b, 21c, 21d, 21e, · · · 21n) and the base lube oil supply pressure ΔP1 is equal or smaller than the minimum permissible pressure difference ΔP_{min}, so that whether abnormality has occurred in lube oil supply due to shortage in valve lift of the electromagnetic valve 17 or other factors can be judged quantitatively for each of the electromagnetic valves 17.

[0049] Therefore, abnormality in lube oil supply can be detected for each of the electromagnetic valves 17 and fast recovery from the abnormality is possible.

[0050] As described above, when malfunction occurs in some of the lubricators 12 or electromagnetic valves 17 for opening /closing the oil passages 16 connecting to the lubricators 12, the oil passages 16 connecting to the concerned lubricators 12 and electromagnetic valves 17 are shutoff by the concerned oil pressure cutoff valves 24, and malfunctioning part can be repaired to restore the normal function of lube oil supply.

[0051] Therefore, when malfunction occurs in the lubricators 12 or electromagnetic valves 17, the concerned oil pressure cutoff valve 24 are actuated to shutoff lube oil supply to the concerned lubricators 12 and electromagnetic valves 17 while continuing engine operation, and malfunctioning part can be repaired to restore normal function without halting the operation of the engine.

[0052] When the malfunctioning part is repaired, normal function is recovered, and a signal for releasing the actuation of the concerned oil pressure cutoff valve 24 is inputted to the controller 19, the controller allows the lube oil supply from the lubricators connected to the malfunctioning lube oil supply line to be recovered upon receiving the signal.

[0053] By composing like this, when the malfunctioning part of the lubricator 12 or electromagnetic valve 17 is repaired, normal function is recovered, and the actuation of the oil pressure cutoff valve is released, the lubricator 12 and electromagnetic valve 17 are allowed to come back automatically to normal operation.

[0054] Further, the controller 19 judges whether malfunction has occurred in the electromagnetic valves 17 (the electromagnetic valves 17a, 17b, 17c, 17d, 17e, · · ·, 17n or the electromagnetic valves 17A, 17B, 17C, and 17D) and the lubricators12a, 12b, 12c, 12d, 12e, · · ·, 12n.

[0055] That is, the controller 19 judges, when the period of time during which the detected lube oil supply pressure inputted from any of the oil pressure sensors 21 (21a, 21b, 21c, 21d, 21e, · · · 21n) exceeds a predetermined threshold value is longer than a permissible period of time, that malfunction has occurred in the concerned electromagnetic valve 17.

[0056] Further, the controller 19 judges, when any of the pressure difference ΔP1 (detected pressure difference) between the peak pressure Pp of the detected lube oil supply pressure inputted from any of the oil pressure sensors 21(21a, 21b, 21c, 21d, 21e, · · · , 21n) and the lube oil pressure detected by the pressure sensor 5 for detecting the pressure in the common lube oil feeding section 15 (the base lube oil pressure Pb may be used instead) is equal or larger than the maximum permissible pressure difference ΔP_{max}, that malfunction has occurred in the concerned lubricator 12 among the lubricators 12a, 12b, 12c, 12d, 12e, · · · , 12n.

[0057] By composing like this, whether there has occurred malfunction in any of the electromagnetic valves 17 and lubricators 12 can be judged by a simple means to compare the detected lube oil supply pressure with the permissible pressures.

[0058] According to the present invention, it is possible to supply the required amount of lube oil at required timing to each lubricator or to eachposition to be lubricated independently and to detect the occurrence of malfunction in lube oil supply action quickly and accurately.Therefore,bytaking measures to cope with the malfunction effectively, a cylinder lubricating system for an internal combustion engine capable of supplying lube oil stably in all over the operation of the engine can be provided.

[0059] According to the invention, it is judged that malfunction has occurred when detected lube oil supply pressure exceeds the pressure of lube oil supply determined beforehand, so that whether abnormality has occurred in lube oil supply due to shortage in valve lift of the electromagnetic valve or other factors can be judged quantitatively for each of the electromagnetic valves.

[0060] Therefore, abnormality in lube oil supply can be detected for each of the electromagnetic valves and lubricators, fast recovery from the abnormality is possible, and occurrence of wear or sticking in the inner surface of cylinder due to deteriorated lubrication as a result of the abnormality of lube oil supply action can be positively evaded.

Claims

1. An internal combustion engine provided with a cylinder lubricating system in which lubricating oil pressure-fed by a lubricating oil pump is accommodated in a common lube oil feeding section, the lubricating oil contained in said common lube oil feeding section is supplied to a plurality of lubricators (injectors) attached to the cylinders of the engine through oil passages connecting said common lube oil feeding section to each of said lubricators respectively and injected to the inner surfaces of cylinders of the engine by said lubricators, wherein are provided a plurality of electromagnetic valves for opening or closing each of said oil passages independently; lube oil supply pressure detectors for detecting pressures of lube oil supplied to the cylinders; and a controller which controls the timing and

period of opening of each of said electromagnetic valves in accordance with the load and rotation speed of the engine, compares the detected lube oil supply pressure of each of the lubricators with a permissible value of lube oil supply pressure, and judges that abnormality has occurred in lube oil supply when the detected lube oil supply pressure exceeds said permissible value.

2. The internal combustion engine provided with a cylinder lubricating system according to claim 1, wherein said controller judges that there has occurred malfunction in lube oil supply when the pressure difference between the peak pressure and base pressure of lube oil supply based on the pressure detected by and inputted from said lube oil supply pressure detector is equal or smaller than a permissible pressure difference determined beforehand.

3. The internal combustion engine provided with a cylinder lubricating system according to claim 1 or 2, wherein said controller determines said permissible pressure difference on the basis of the period of the electromagnetic valve and the pressure in the common lube oil feeding section.

4. The internal combustion engine provided with a cylinder lubricating system according to one of claims 1 to 3, wherein the controller judges that malfunction has occurred in the electromagnetic valve when a period of time during which the detected lube oil supply pressure exceeds a predetermined threshold value is longer than a permissible period of time.

5. The internal combustion engine provided with a cylinder lubricating system according to one of claims 1 to 4, wherein said controller judges that malfunction has occurred in the lubricator when the pressure difference between peak pressure of the detected lube oil supply pressure and the pressure in the common lube oil feeding section is equal or larger than a permissible pressure difference determined beforehand.

6. An internal combustion engine provided with a cylinder lubricating system in which lubricating oil pressure-fed by a lubricating oil pump is accommodated in a common lube oil feeding section, the lubricating oil contained in said common lube oil feeding section is supplied to a plurality of lubricators (injectors) attached to the cylinders of the engine through oil passages connecting said common lube oil feeding section to each of said lubricators respectively and injected to the inner surfaces of cylinders of the engine by said lubricators, wherein are provided a plurality of electromagnetic valves for opening/closing oil passages connecting to a plurality of said lubricators respectively, oil pressure cutoff valves attached to oil passages connecting the electromagnetic valves to the common lube oil feeding section for shutting off said oil passages, and an oil cutoff valve actuating means for allowing said oil cutoff valve actuating means to actuate when malfunction occurs in lube oil supply operation performed by the lubricators and controlled by the electromagnetic valves.

7. The internal combustion engine provided with a cylinder lubricating system according to claim 6, wherein a controller is provided which allows the lube oil supply by the lubricators to be restored upon receiving a signal to release the actuation of the oil pressure cutoff valve when it is inputted to the controller.

FIG. 1

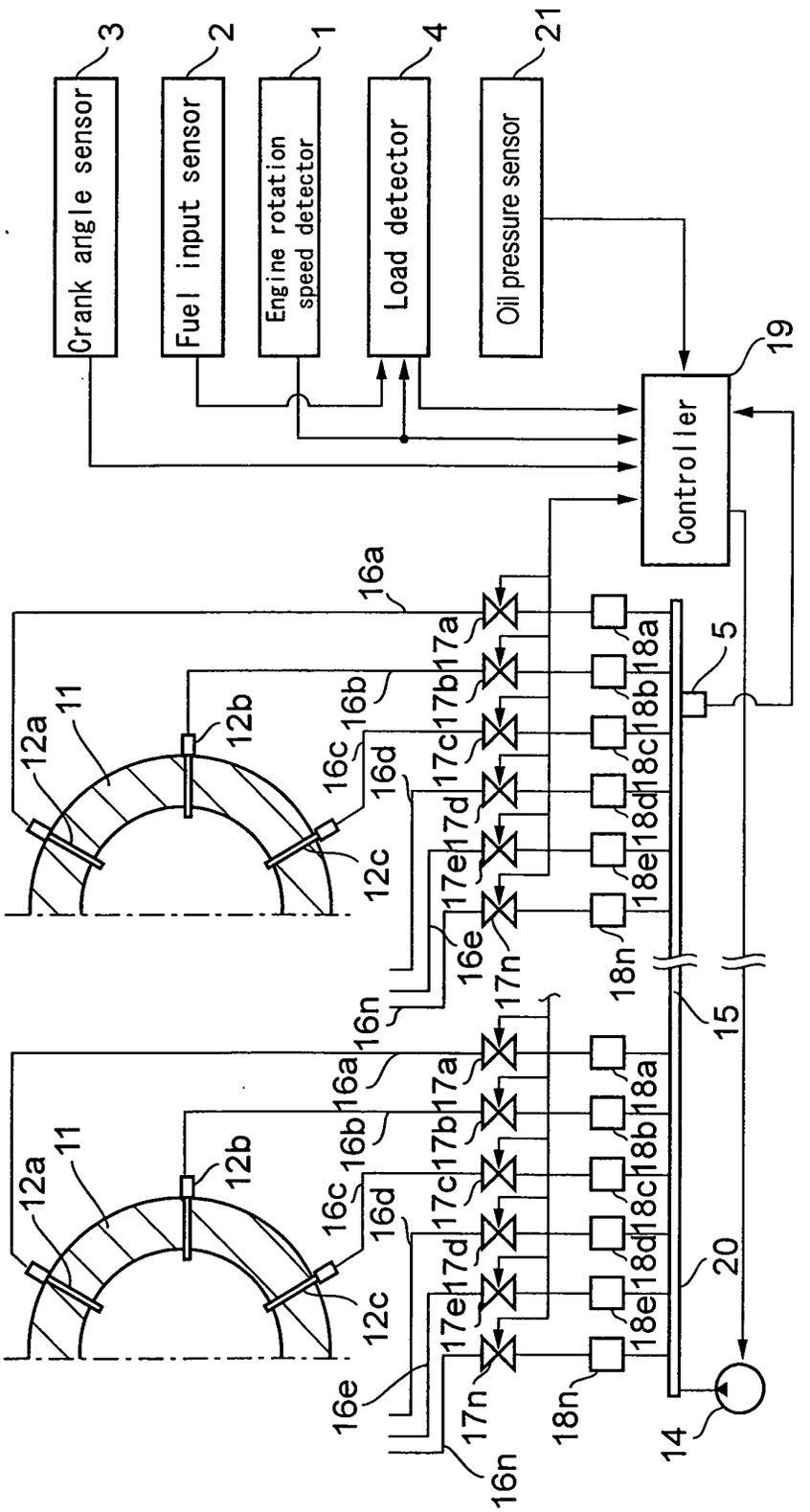
Crank angle sensor
3
Fuel input sensor
2
Engine rotation speed detector
1
Load detector
4
Oil pressure sensor
21
Controller
19
5
15
20
14
11
12a
12b
12c
16a
16b
16c
16d
16e
16n
17a
17b
17c
17d
17e
17n
18a
18b
18c
18d
18e
18n

FIG. 2

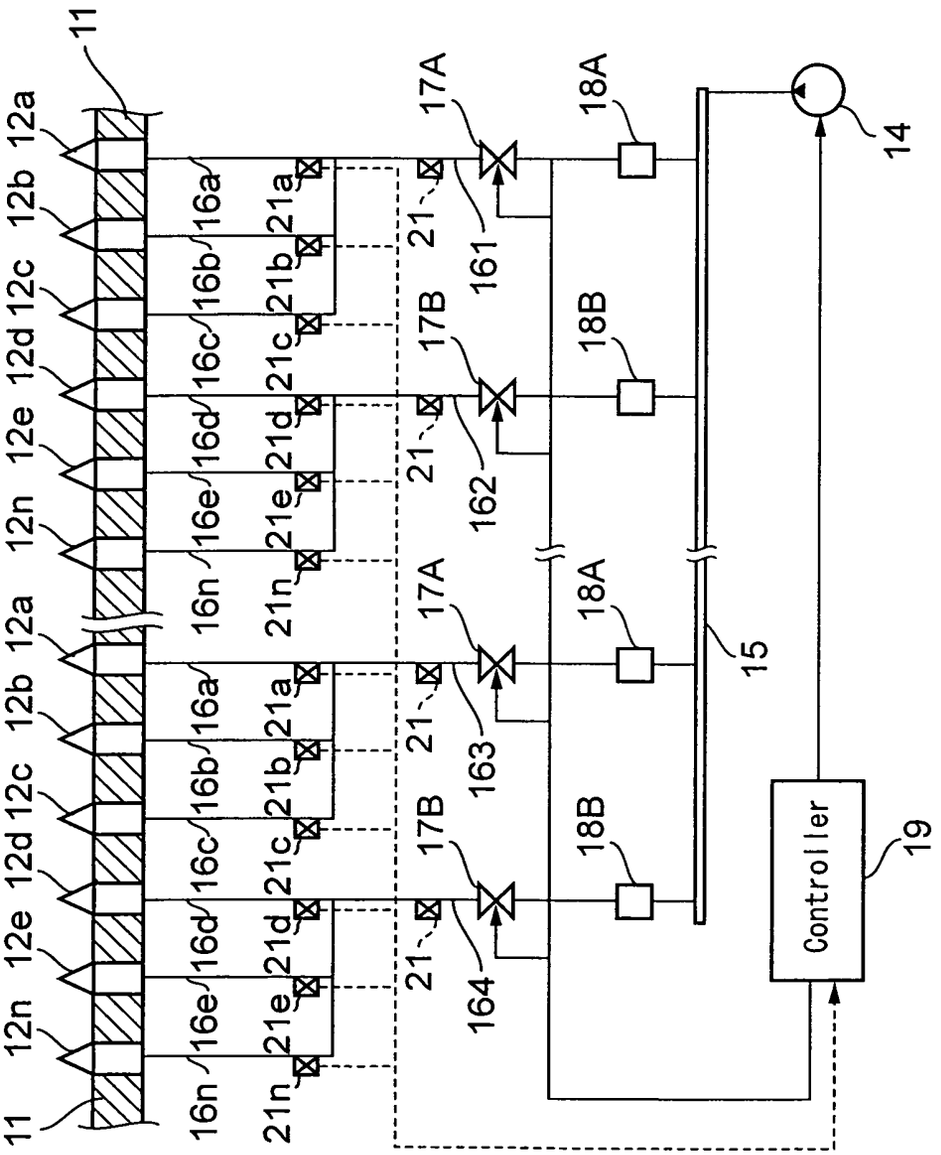
11
12a
12b
12c
12d
12e
12n
16a
16b
16c
16d
16e
16n
21a
21b
21c
21d
21e
21n
17A
17B
161
162
163
164
18A
18B
14
15
Controller
19

FIG. 3

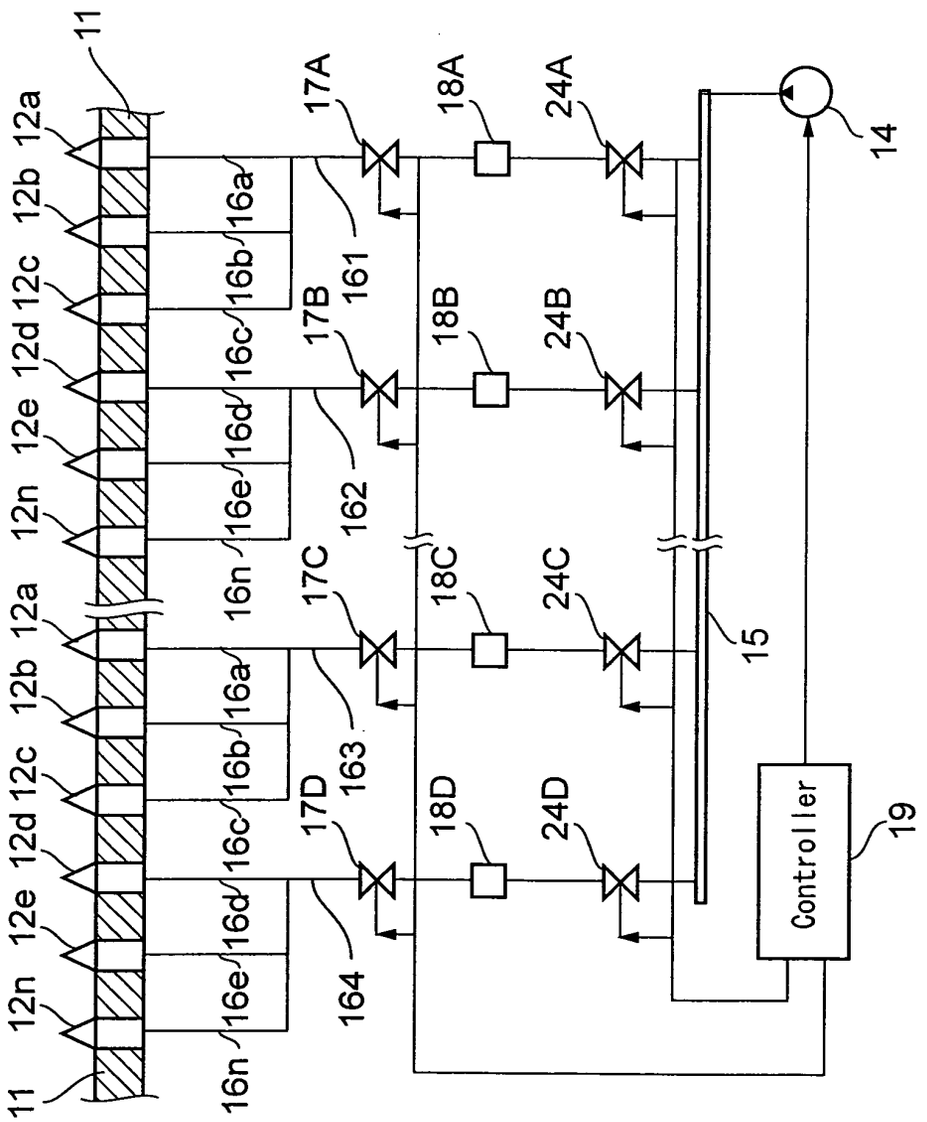
11
12a
12b
12c
12d
12e
12n
11
16a
16b
16c
16d
16e
16n
17A
17B
17C
17D
161
162
163
164
18A
18B
18C
18D
24A
24B
24C
24D
15
14
Controller
19

FIG. 4

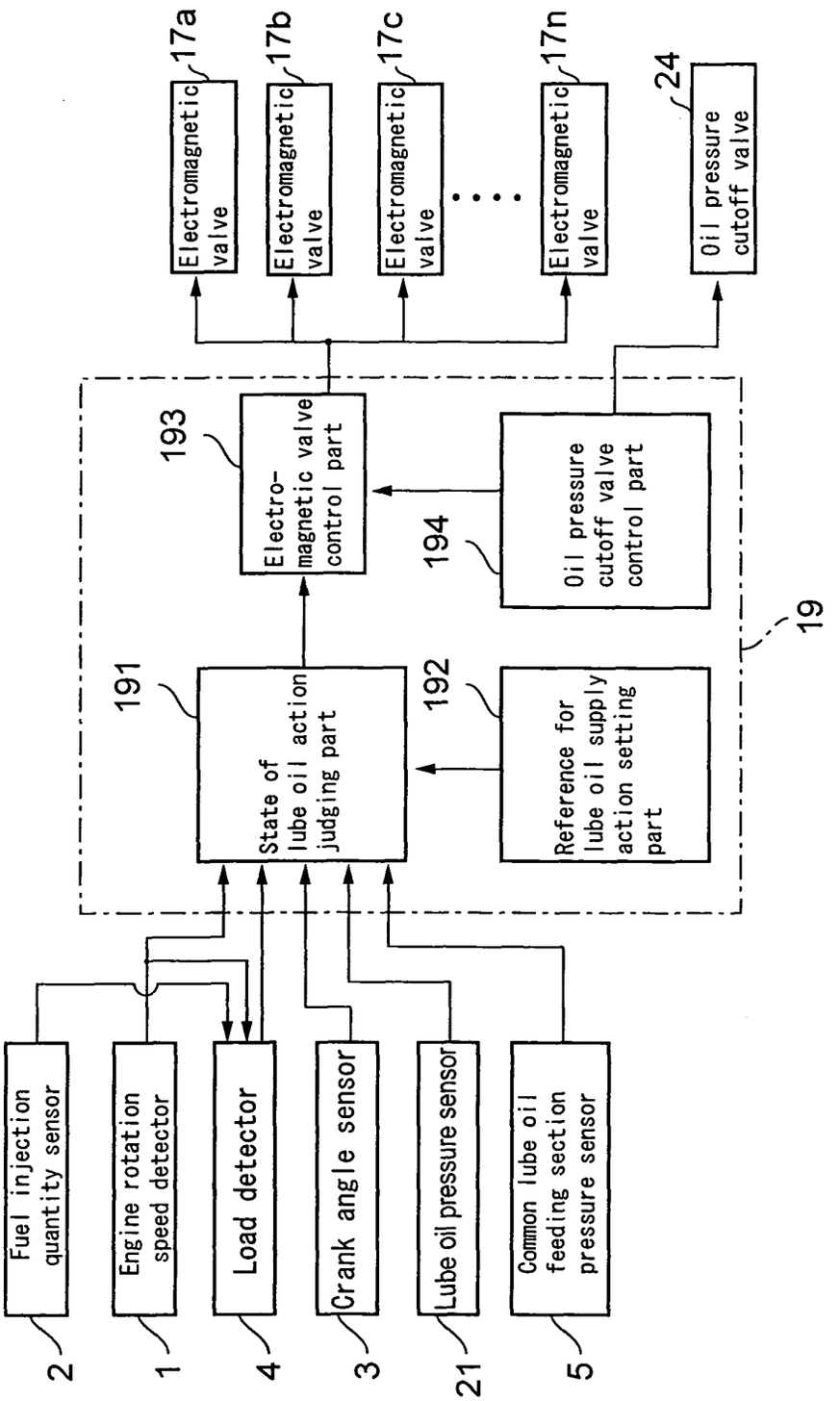
Fuel injection quantity sensor
Engine rotation speed detector
Load detector
Crank angle sensor
Lube oil pressure sensor
Common lube oil feeding section pressure sensor
2
1
4
3
21
5
19
State of lube oil action judging part
191
Reference for lube oil supply action setting part
192
Electro-magnetic valve control part
193
Oil pressure cutoff valve control part
194
Electromagnetic valve
17a
Electromagnetic valve
17b
Electromagnetic valve
17c
Electromagnetic valve
17n
Oil pressure cutoff valve
24

FIG. 5

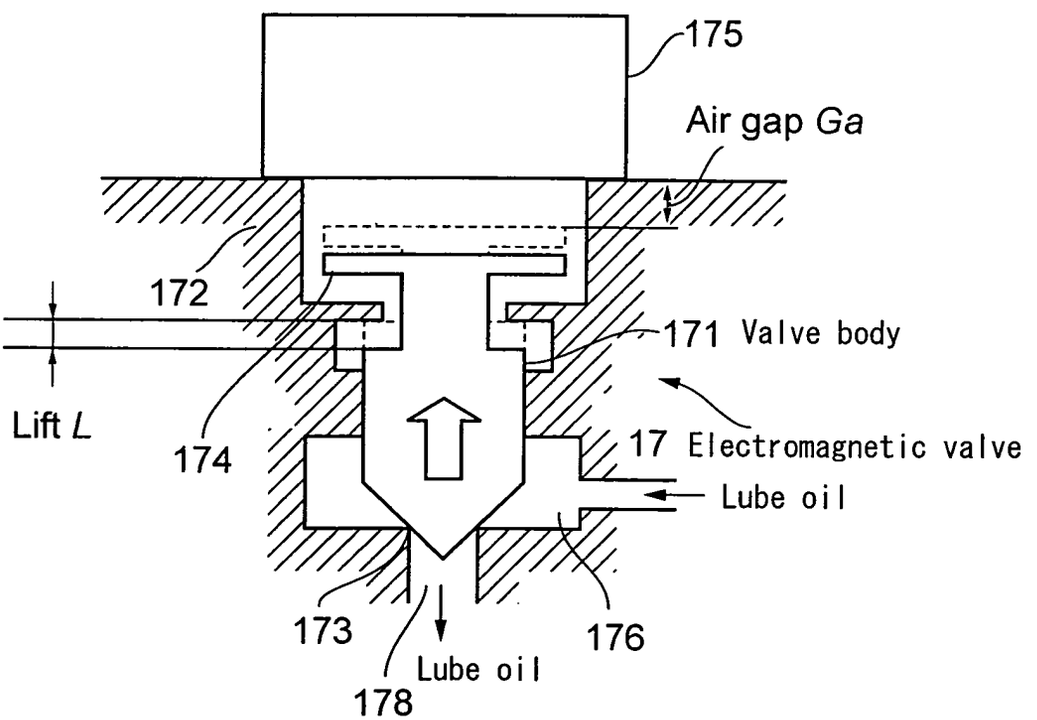
175
Air gap Ga
172
171 Valve body
Lift L
174
17 Electromagnetic valve
Lube oil
173
176
Lube oil
178

FIG. 6