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(54) Four-stroke cycle engine

(57) A four-stroke cycle engine having an intake passage and an exhaust passage both opening to a combustion chamber, and having an intake valve for opening and closing the intake passage and an exhaust valve for opening and closing the exhaust passage, with blowby leaking from the combustion chamber into a crank chamber returned to the intake passage through a circulation passage and with the circulation passage. A fresh air intake passage is provided to make fluid communication between part of the intake passage on the upstream side of a throttle valve and the crank chamber, with the fresh air intake passage provided with a fresh air inflow valve.

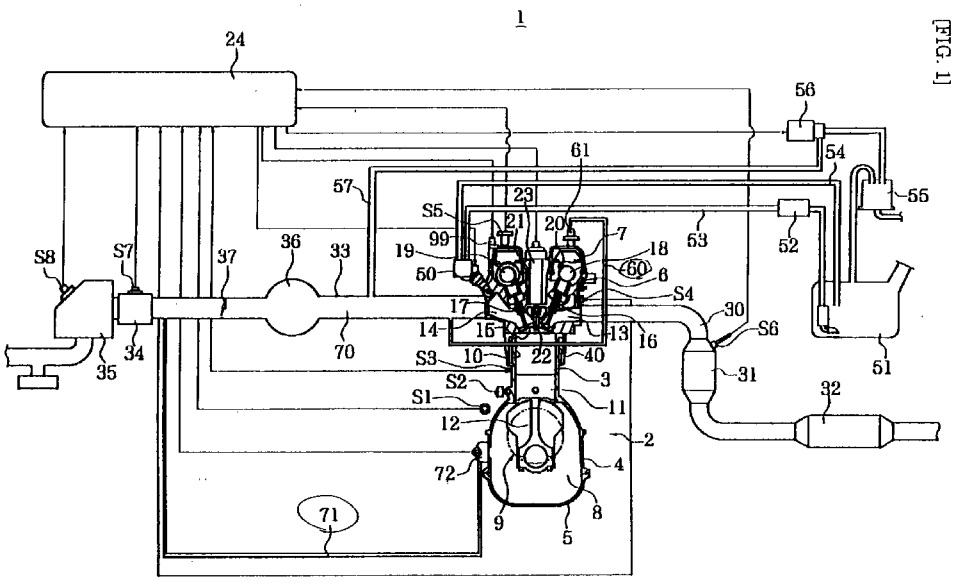

FIG. 1

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Description

[0001] This invention relates to a four-stroke cycle engine having an intake passage and an exhaust passage both opening to a combustion chamber, and having an intake valve for opening and closing the intake passage and an exhaust valve for opening and closing the exhaust passage, with blowby leaking from the combustion chamber into a crank chamber returned to the intake passage through a circulation passage and with the circulation passage.

[0002] In four-stroke cycle engines of such types as with single cylinder, two cylinders, three cylinders, or V-bank multiple cylinders, pressure in the crank chamber pulsates as the pistons operate. The pulsation is particularly great in engines in which air of the same amount as the displacement moves inside the crank chamber. As a result, problems such as oil leak occurs.

[0003] To prevent the crank chamber internal pressure from pulsating, there is an arrangement in which a fresh air inflow passage is formed in the crank chamber and the fresh air inflow passage is provided with a check valve such as a reed valve. However, such an arrangement does not provide circulation of fresh air through the inside of the engine, and is disadvantageous in that the inside is soiled with sludge and oil is deteriorated.

[0004] Another arrangement for increasing the combustion efficiency by producing turbulence in the combustion chamber in the cylinder is provided with a sub-intake passage. In conventional arrangement, the intake flow rate through the sub-intake passage is determined with the main intake passage flow rate or the intake pressure and therefore combustion chamber internal turbulence required for stabilized combustion varies with the engine load. However, the variation cannot satisfy the requirement.

[0005] Accordingly, it is an objective of the invention is to provide a four-stroke cycle engine as indicated above which is capable of maintaining the interior of the crank chamber at negative pressures, reducing soil in the engine, reducing oil deterioration, lowering the crank chamber internal pressure, reducing pulsation loss, and improving fuel economy.

[0006] According to the present invention, this objective is solved for a four-stroke cycle engine as indicated above in that a fresh air intake passage is provided to make fluid communication between part of the intake passage on the upstream side of a throttle valve and the crank chamber, with the fresh air intake passage provided with a fresh air inflow valve.

[0007] According to an advantageous embodiment of the present invention, the circulation passage has a return flow rate controller.

[0008] According to another embodiment of the invention as claimed in claim 3, it is possible to keep the interior of the crank chamber at negative pressures, reduce soil in the interior of the engine, reduce deterioration of oil, lower crank chamber internal pressure, reduce pulsation loss, and improve fuel economy by providing the fresh air inflow passage with the fresh air inflow control valve, providing the circulation passage with the return flow rate control valve, and setting the flow rate through the fresh air inflow rate through the fresh air inflow passage smaller than the flow rate through the return flow rate control valve.

[0009] The invention recited in claim 4 is based on the four-stroke cycle engine recited in claim 1, characterized in that a check valve is provided in the circulation passage to prevent reverse flow from the intake passage toward the crank chamber.

[0010] With the invention recited in claim 4, since the check valve is provided in the circulation passage to prevent reverse flow from the intake passage toward the crank chamber, reverse flow from the intake passage toward the crank chamber is prevented in the high load range.

[0011] To further enhance the present invention and to provide a four-stroke cycle engine capable of freely controlling the flow rate through the intake passage utilizing the crank chamber internal pressure pulsation, producing intake turbulence commensurate with loads, stabilizing cold engine combustion, improving ease of driving, further improving fuel economy, and improving exhaust property, it is advantageous when the return port of the circulation passage is disposed in the opening area of the intake passage which opens to the combustion chamber.

[0012] With this invention, since the return port of the circulation passage is disposed in the opening area of the intake passage opening to the combustion chamber, it is possible by utilizing the pulsation of internal pressure in the crank chamber to freely control the flow rate through the intake passage and produce intake turbulence commensurate with loads, stabilize cold engine combustion, and improve ease of drive, fuel economy, and emission property.

[0013] The invention recited in claim 6 is a four-stroke cycle engine of one of claims 1 to 3, characterized in that a control means is provided to produce negative pressures in the crank chamber over the entire range from low to high loads by controlling the fresh air inflow control valve and the return flow rate control valve.

[0014] With invention recited in claim 6, since the internal pressure in the crank chamber is made negative over the entire range from low to high loads by controlling the fresh air inflow control valve and the return flow rate control valve, internal soil of the engine and deterioration of oil are all the more reduced, pulsation loss is reduced, and fuel economy is improved.

[0015] Other preferred embodiments of the present invention are laid down in further dependent claims.

[0016] In the following, the present invention is explained in greater detail with respect to several embodiments thereof in conjunction with the accompanying drawings, wherein:

FIG. 1 shows a general constitution of the four-stroke cycle engine; and

FIG. 2 shows a general constitution of another embodiment of the four-stroke cycle engine.

[0017] In FIG. 1 the four-stroke cycle engine 1 of this embodiment is of any type; with a single cylinder, two cylinders, three cylinders, or multiple cylinders arranged in V-banks, in which the crankcase internal pressure pulsates with the movement of a piston or pistons.

[0018] The main body 2 of the four-stroke cycle engine 1 comprises a cylinder block 3, a crankcase 4, an oil pan 5, a cylinder head 6, a head cover 7, and others. A crankshaft 9 disposed in a crank chamber 8 defined with the cylinder block 3, crankcase 4, and the oil pan 5 is shaft-supported between the cylinder block 3 and the crankcase 4. A piston 11 is disposed for reciprocal movement in a cylinder bore 10 in the cylinder block 3. The piston 11 is connected through a connecting rod 12 to the crankshaft 9.

[0019] The crankcase 4 is provided with a crank angle sensor S1, an oil pressure sensor S2, and a knocking sensor S3. Signals from those sensors are sent to a controller 24. The cylinder block 3 and the cylinder head 6 are provided with water jackets. A temperature sensor S4 is disposed in the cylinder head 6, from which engine temperature signals are sent to the controller 24.

[0020] In the cylinder head 6 are formed an exhaust passage 13 and an intake passage 14, with their openings to the combustion chamber 15 are opened and closed with an exhaust valve 16 and an intake valve 17, respectively. The exhaust valve 16 and the intake valve 17 are driven with cams 20 and 21 formed on camshafts 18 and 19, respectively. The camshafts 18 and 19 are rotated by way of cam chains (not shown) with the crankshaft 9. A cam sensor S5 is provided on the head cover 7 to send cam angle signals to the controller 24. The cam 21 provided on the intake side of the camshaft 19 is adapted to control by way of the controller 24 a variable valve drive mechanism 99 to change the cam position responsive to operating conditions of the engine (1).

[0021] An ignition plug 22 is disposed in the cylinder head 6 with its tip facing the combustion chamber 15. The ignition plug 22 is connected to an ignition coil 23 for producing a high voltage responsive to an ignition signal from the controller 24, and produces sparks for ignition.

[0022] The cylinder head 6 is connected through the exhaust passage 13 to an exhaust pipe 30, and provided with catalyst devices 31 and 32 in two positions to purify emissions. The catalyst device 31 is provided with an exhaust temperature sensor S6 to send exhaust temperature signals to the controller 24.

[0023] An intake pipe 33 is connected by way of the intake passage 14 to the cylinder head 6, and further connected to an air flow meter 34, and an air cleaner 35. The intake pipe 33 is further provided with a surge tank 36 and a throttle valve 37. The air flow meter 34 is provided with a mass flow sensor S7, and the air cleaner 35 is provided with an intake air temperature sensor S8, to send respective signals to the controller 24.

[0024] The cylinder head 6 is also provided with a fuel injection valve 50 for injecting fuel into the intake passage 14. Fuel in a fuel tank 51 is supplied to the fuel injection valve 50 by way of a fuel supply pipe 53 as a fuel pump 52 is driven. Surplus fuel is returned from the fuel injection valve 50 to the fuel tank 51 by way of a fuel return pipe 54. The fuel injection valve 50 is controlled with the controller 24.

[0025] The fuel tank 51 is connected to a vapor separator 55 to separate air content from fuel content. The air content is sent to an intake passage 70 of an intake pipe 33 on the downstream side of the surge tank 36 by way of an air supply passage 57 as a supply pump 56 is driven. The supply pump 56 is controlled with the controller 24.

[0026] The blowby leaking from the combustion chamber 15 through the gap between the piston 11 and the cylinder bore 10 as the piston 11 reciprocates is returned by way of a circulation passage 60 to the intake passage 70 of the intake pipe 33 on the downstream side of the surge tank 36. The circulation passage 60 is provided with a return flow rate control valve 61 for controlling the return flow rate. The return flow rate control valve 61 is constituted with a pressure control valve (PCV).

[0027] A fresh air inflow passage 71 is provided to make fluid interconnection between part of the intake passage 70 on the upstream side of the throttle valve 37 and the crank chamber 8. A fresh air inflow control valve 72 is disposed in the fresh air inflow passage 71. The flow rate through the fresh air inflow control valve 72 is controlled to be smaller than that through the return flow rate control valve 61. This makes it possible to maintain the internal pressure of the crank chamber 8 negative, as fresh air flows from the fresh air inflow passage 71 as the piston 11 reciprocates and mixes with the blowby leaking through the gap between the piston 11 and the cylinder bore 10 and is returned by way of the circulation passage 60 to the intake passage 70, on the downstream side of the surge tank 36, of the intake pipe 33. Introducing fresh air into the crank chamber 8 and circulating it as described above makes it possible to reduce soil in the interior of the engine, reduce deterioration of oil, and moreover to make the internal pressure of the crank chamber 8 negative, which in turn makes it possible to maintain the internal pressure of the crank chamber 8 low, reduce pulsation loss, and improve fuel economy.

[0028] The fresh air inflow control valve 72 and the return flow rate control valve 61 are controlled with a controller 24 constituting a control means using a con-

trol map associated with pre-stored valve opening degrees and engine operating conditions over the entire range from low to high loads to maintain the interior of the crank chamber 8 at negative pressures. This control further makes it possible to reduce soil in the engine interior, reduce oil deterioration, lower the crank chamber internal pressure, and improve fuel economy.

[0029] FIG. 2 is a general constitution drawing of another embodiment of the four-stroke cycle engine. In the drawing, the same parts as those in the first embodiment shown in FIG. 1 are provided with the same reference numerals and their descriptions are omitted.

[0030] In the four-stroke cycle engine 1 of this embodiment, a check valve 80 and the return flow rate control valve 61 are provided in the circulation passage 60 to prevent reverse flow from the intake passage 14, which is open to the combustion chamber 15, toward the crank chamber. The return flow rate control valve 61 is constituted with a duty valve. Thus, it is possible to prevent the reverse flow from the intake passage 14 side is prevented in the high load range.

[0031] And, since the return port 61a of the circulation passage 60 is provided in the opening area of the intake passage 14 which is open to the combustion chamber 15, swirl is produced in the combustion chamber 15 by the rapid air flow returning from the return port 61a. The return flow rate control valve 61 makes it possible to freely control the flow rate through the intake passage 14; for example toward closing side at low loads and toward opening side at high loads. In this way, it is possible to produce intake turbulence commensurate with requirement according to loads, to stabilize combustion when the engine is cold, to improve ease of drive, and to improve fuel economy.

[0032] As described above, with the invention of claim 1, the fresh air inflow control valve is disposed in the fresh air inflow passage and the return flow rate control valve is disposed in the circulation passage, and the flow rate through the fresh air inflow control valve is made smaller than the flow rate through the return flow rate control valve, to make it possible to maintain the internal pressure of the crank chamber 8 low, reduce soil in the interior of the engine, reduce oil deterioration, lower crank chamber internal pressure, and improve fuel economy.

[0033] With the invention of claim 2, since the check valve is provided in the circulation passage to prevent reverse flow from the intake passage to the crank chamber side, the reverse flow from the intake passage side is prevented in the high load range.

[0034] With the invention of claim 3, since the return port of the circulation passage is disposed in the opening area of the intake passage opening to the combustion chamber, it is possible to freely control the flow rate through the intake passage utilizing the pulsation of the crank chamber internal pressure, produce intake turbulence meeting requirement according to the load, stabilize cold engine combustion, improve driveability and fuel economy.

[0035] With the invention of claim 4, since the crank chamber internal pressure is made negative over the entire range from low to high loads by controlling the fresh air inflow control valve and the return flow rate control valve, it is further possible to reduce soil in the engine interior, reduce oil deterioration, lower the crank chamber internal pressure, reduce pulsation loss, and improve fuel economy.

Claims

1. A four-stroke cycle engine (1) having an intake passage (14) and an exhaust passage (30) both opening to a combustion chamber (15), and having an intake valve (17) for opening and closing the intake passage (14) and an exhaust valve (16) for opening and closing the exhaust passage (30), with blowby leaking from the combustion chamber (15) into a crank chamber (8) returned to the intake passage (14) through a circulation passage (60) and with the circulation passage (60),
characterized in that
a fresh air intake passage (71) is provided to make fluid communication between part of the intake passage (14) on the upstream side of a throttle valve (37) and the crank chamber (8), with the fresh air intake passage (71) provided with a fresh air inflow valve (72).

2. A four-stroke cycle engine (1) according to claim 1, **characterized in that** the circulation passage (60) having a return flow rate control valve (61).

3. A four-stroke cycle engine (1) according to claim 1 or 2, **characterized in that** the fresh air inflow valve is a fresh air inflow control valve (72) for controlling the inflow rate of the fresh air, whereas the fresh air inflow control valve (72) and/or the return flow rate control valve (61) being controllable such that the inflow rate through the fresh air inflow control valve (72) being smaller than the flow rate through the return flow rate valve (61).

4. A four-stroke cycle engine (1) according to at least one of the preceding claims 1 to 3, **characterized in that** a check valve (80) is provided in the circulation passage (60) to prevent reverse flow from the intake passage (14) toward the crank chamber (8).

5. A four-stroke cycle engine (1) according to at least one of the preceding claims 1 to 4, **characterized in that** a return port (61a) of the circulation passage (60) is disposed in the opening area of the intake passage (14) which opens to the combustion chamber (15).

6. A four-stroke cycle engine (1) according to at least

one of the preceding claims 1 to 5, **characterized in that** a control means (24) is provided to produce negative pressures in the crank chamber (8) over the entire range from low to high loads by controlling the fresh air inflow control valve (72) and the return flow rate control valve (61).

7. A four-stroke cycle engine (1) according to at least one of the preceding claims 1 to 6, **characterized by** a crank angle sensor (S1), an oil pressure sensor (S2), a knocking sensor (S3), a temperature sensor (S4), a cam sensor (S5), an exhaust temperature sensor (S6), a mass flow sensor (S7), and an intake air temperature sensor (S8) all generating signals to control said engine (1).

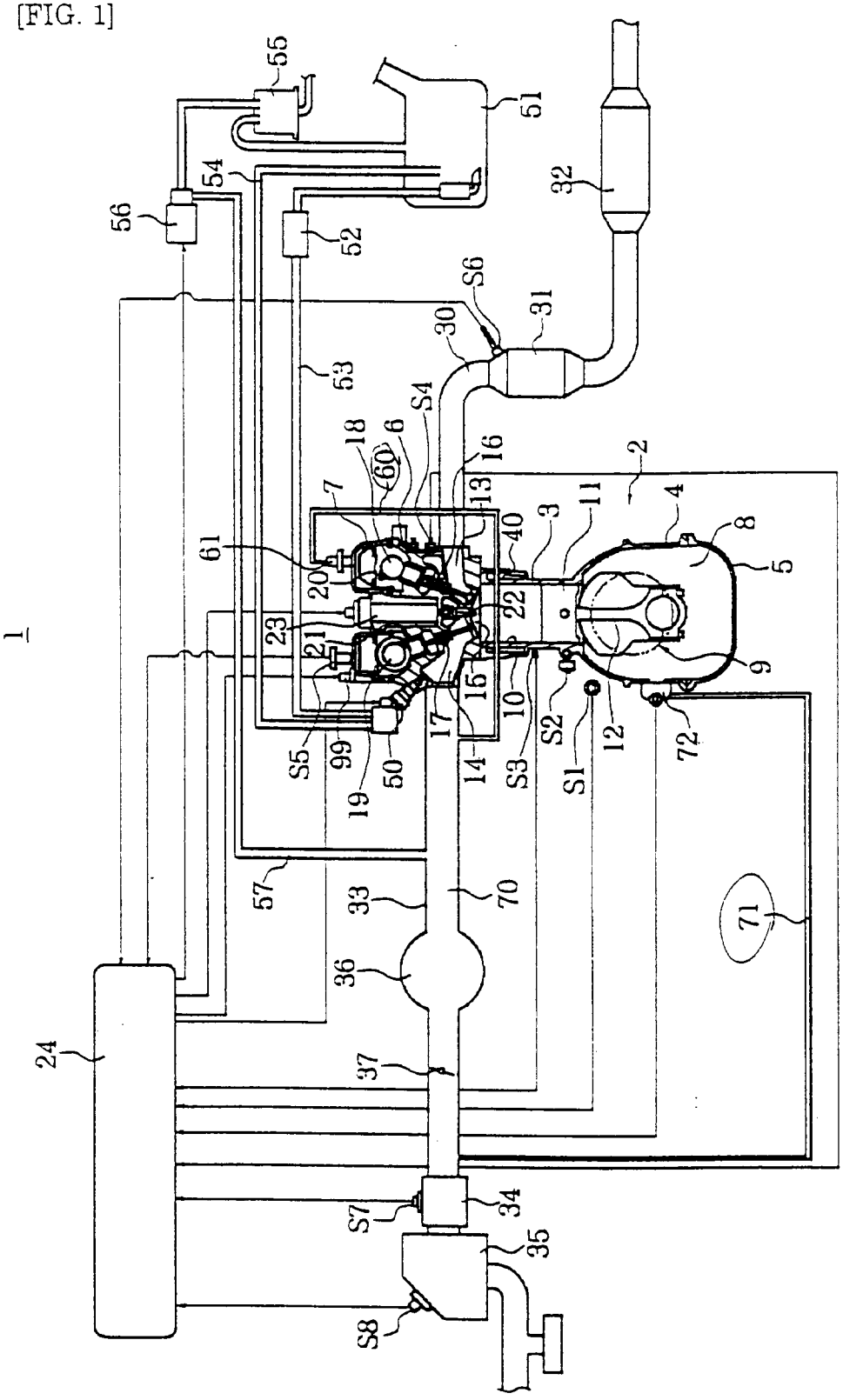
8. A four-stroke cycle engine (1) according to at least one of the preceding claims 1 to 7, **characterized by** a variable valve drive mechanism (99) to change cam positions in accordance with engine operation conditions.

9. A four-stroke cycle engine (1) according to at least one of the preceding claims 1 to 8, **characterized in that** a fuel tank (51) is connected with a vapor separator (55) for separating air out of the fuel and supplying said air via an air supply passage (57) to an intake pipe (33).

10. A four-stroke cycle engine (1) according to at least one of the preceding claims 3 to 9, **characterized in that** said return flow rate valve (61) is constituted with a pressure control valve (PCV).

11. A four-stroke cycle engine (1) according to at least one of the preceding claims 6 to 10, **characterized in that** said control means (24) being provided with a control map containing pre-stored valve opening degrees and engine operation conditions over the entire range from low to high loads to maintain the interior of the crankchamber (8) at negative pressures.

[FIG. 1]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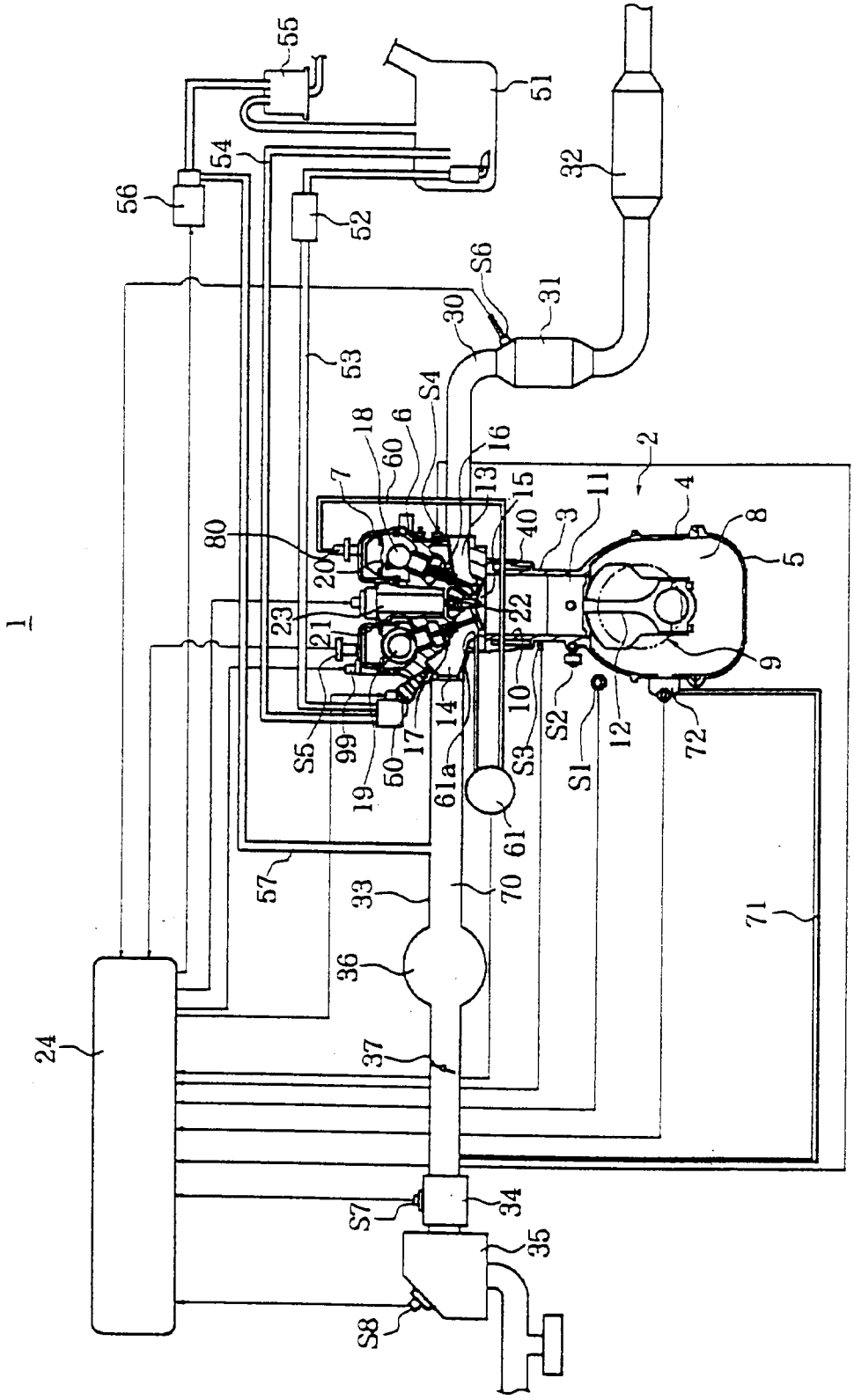
[FIG. 2]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