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(71) Applicant: **Rise Pit Company Co., Ltd.**
Tokyo 141-0021 (JP)

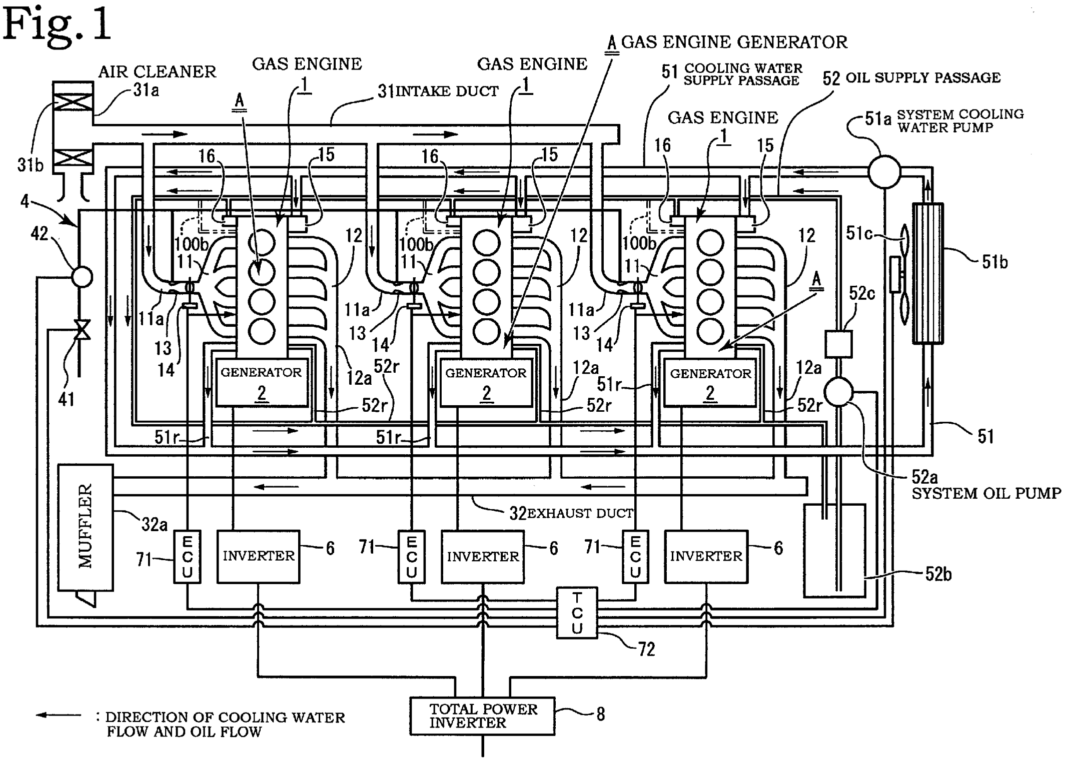
(72) Inventor: **YAMAZAKI, Takahiro**
Shinagawa-ku
Tokyo, Tokyo 141-0021 (JP)

(74) Representative: **Grünecker Patent- und Rechtsanwälte**
PartG mbB
Leopoldstraße 4
80802 München (DE)

(54) **GAS ENGINE GENERATOR SYSTEM**

(57) The system includes a plurality of gas engines, generators connected to the gas engines, a cooling water supply passage for supplying cooling water to each gas engine, and a system cooling water pump that circulates the cooling water. The plurality of gas engines are arranged parallel to the cooling water supply passage. When the system is running, at least one gas engine is driven, while all the gas engines are kept warmed up via the cooling water supply passage. The remaining gas engines are driven successively in accordance with an increase in power demand.

Fig. 1



EP 3 705 708 A1

Description

[0001] The present invention relates to a gas engine generator system having a plurality of gas engines and capable of running accordingly to the increase and decrease in the amount of power demand.

[0002] Small engine generators that combine a small engine and a generator coupled together have come in various types so far. Among these, a spark-ignited gas engine that runs on liquefied petroleum gas (LPG) or compressed natural gas (CNG) is advantageous in terms of simplicity and environmental friendliness as the power source of an independent, discrete generator.

[0003] Since gas engines are reciprocating piston engines, when driven at a constant rpm and an air-fuel ratio, the smaller the load, the lower the thermal efficiency. When idling, the thermal efficiency is zero, which means the engine only consumes fuel while doing no work externally.

[0004] The volume of one cylinder of a spark-ignited engine is limited because of the constraint posed by flame propagation. Compression-ignited diesel engines are less limited in this respect, and a single diesel engine for ships can generate power as high as several tens of thousands of kilowatts. Gas engines on the other hand generate several hundred kilowatts. The electrical load of an individual generator ranges from zero to about 500 kilowatts. Sometimes a maximum power demand cannot be supplied by one engine. In this case, a number of engine generators made up of pairs of engines and generators have to be provided in parallel arrangement to produce power.

[0005] When the power demand is low, the large engine is driven to output a low power. The degree of opening of the throttle is reduced in this case, which deteriorates thermal efficiency. It is therefore preferable to use fewer engines when the power demand is low so that one engine outputs a larger power, and to increase the number of engines correspondingly as the power demand increases. This means that when there is a sudden surge in electrical load demand, another engine needs to be started up quickly. Engines, however, require a warm-up time. A cold engine cannot produce high power due to the poor quality of combustion in the cylinder and a large friction loss. The gap between the piston and the cylinder becomes larger because of which oil may penetrate into the combustion chamber, resulting in a plume of white smoke or increased oil consumption.

[0006] Japanese Patent Application Laid-open Nos. H 02-262846 and H 09-195811 describe a system having a plurality of engines and generators arranged in parallel, wherein all the engines run constantly, and the way the engines are driven is not changed in accordance with an increase or decrease of power demand. Accordingly, an object of the invention (or a technical problem to be solved) is to provide a gas engine generator system that is operated adaptively to the increase and decrease in the amount of power demand and capable of achieving an optimal drive efficiency of each of small engines.

[0007] Through intensive research, the inventors of the present application came up with the present invention to solve the problems described above, a first aspect thereof being a gas engine generator system including: a plurality of gas engines, generators connected to the gas engines, a cooling water supply passage for supplying cooling water to each of the gas engines, a system cooling water pump that circulates the cooling water, and engine water pumps each provided to each of the gas engines, the plurality of gas engines and the plurality of engine water pumps being arranged in parallel to the cooling water supply passage, the system cooling water pump being kept running when even one of the gas engines is running, so as to keep other engines that are stopped warmed up by the cooling water circulating in the cooling water supply passage, at least one of the gas engines being operated at first, with remaining gas engines being run successively in accordance with an increase in power demand, the system further including a total control unit (TCU), the total control unit (TCU) sending signals to select, run, and stop the plurality of gas engines to run the gas engines proportionately such that all of the gas engines have a constant rpm.

[0008] A second aspect of the present invention made to solve the problems described above is that, in the gas engine generator system according to the first aspect, each of the gas engines has an oil pan in which a minimum amount of oil necessary at start-up remains, while the system includes an independent oil tank capable of supplying oil to all of the gas engines.

[0009] A third aspect of the present invention made to solve the problems described above is that, in the gas engine generator system according to first or second aspect, all the gas engines, the generators, and engine control units are accommodated in a single housing as a package, the system being configured with one air cleaner to filter air to be supplied for combustion to all the gas engines, and one muffler to reduce noise emitted by exhausts from all the gas engines.

[0010] A fourth aspect of the present invention made to solve the problems described above is that, in the gas engine generator system according to the third aspect, each of the plurality of gas engines in the package is equipped with an electric engine water pump, an electric engine oil pump, an oil filter, and a system oil tank.

[0011] A fifth aspect of the present invention made to solve the problems described above is that, in the gas engine generator according to the first or second aspect, the system includes three or more gas engines.

[0012] According to the present invention, when the generator system is running, the cooling water is kept circulating in the cooling water supply passage so that all the gas engines, whether running or stopped, are kept warmed up. When the power demand is low, at least one gas engine is operated (run), while the remaining gas engines are run successively in accordance with an increase in the amount of power demand.

[0013] Since the plurality of gas engines including those that are stopped are kept warmed up by the cooling water circulated by the system cooling water pump in the cooling water supply passage when the generator system is running as described above, when the gas engines that are stopped are required to start up in response to an increase in power demand, they can start up immediately and start running in a stable and favorable condition shortly. The plurality of gas engines can thus run cost-effectively, as each of them can be driven with an optimal operation efficiency.

[0014] Moreover, according to the present invention, the generator system includes a total control unit (TCU), which sends signals to serve the function of selecting, running, and stopping the plurality of gas engines to run the gas engines proportionately. Therefore, when the generator system is running, the gas engine that is started up first among the plurality of gas engines, and the gas engines that are started up second and onwards successively with an increase in power demand, can be differed each time. Thus the gas engine that is started up first is chosen equally so that intensive start-up of a specific gas engine is prevented in the operation of the generator system, which leads to a prolonged service life of the generator system itself.

FIG. 1 is an entire view illustrating the configuration of a generator system;
FIG. 2 is a schematic perspective view of mechanical parts of the generator system;
FIG. 3 is a diagram showing the relationship between the degree of throttle opening and thermal efficiency of an engine;
FIG. 4 is a diagram showing the number of engines driven in accordance with an increase in electrical load demand;
FIG. 5 is a diagram showing the influence of the temperature of cooling water on the thermal efficiency of an engine;
FIG. 6 is a diagram illustrating a simple method of storing a preset amount of oil in an oil pan of each engine; and
FIGS. 7A to 7C are diagrams illustrating how more and more gas engines are started up with an increase in power demand in the generator system of the present invention.

[0015] One embodiment of the present invention will be described with reference to the drawings. A gas engine generator system of the present invention is generally made up of gas engines 1, generators 2, a cooling water supply passage 51, a system cooling water pump 51a, an oil supply passage 52, a system oil pump 52a, and so on. First of all, the gas engines 1 in the gas engine generator system are small to medium size gas engines. More particularly, they are gas engines that run on liquefied petroleum gas (LPG), compressed natural gas (CNG), or liquefied natural gas (LNG). These gas engines can also run on the propane-butane gas mixture commonly used for domestic purposes as well as utility gas. The system includes a plurality of such gas engines 1 (see FIGS. 1 and 2).

[0016] While the gas engine generator system includes three gas engines 1 in this embodiment, some systems may include four or more gas engines, or just two gas engines. A generator 2 is mounted to each of the plurality of gas engines 1. The gas engine 1 and generator 2 make up a single gas engine generator A. A plurality of gas engine generators A, A, ... are arranged in parallel, which, with necessary equipment added thereto, make up the gas engine generator system (see FIGS. 1 and 2).

[0017] The gas engine generators A, A, ... arranged in parallel in the gas engine generator system share an intake duct 31 and an exhaust duct 32. Each gas engine 1 has an intake manifold 11 for taking in the air, and an exhaust manifold 12 for exhausting gases. The intake manifold 11 includes an intake branch pipe 11a, and is connected to the intake duct 11 through this intake branch pipe 11a. The exhaust manifold 12 includes an exhaust branch pipe 12a, and is connected to the exhaust duct 32 through this exhaust branch pipe 12a. The exhaust branch pipes 12a of the exhaust manifolds 12 of the plurality of gas engines 1 are connected to an exhaust port of the exhaust duct 32 shared by the plurality of gas engines 1, 1, ... where the exhaust gas is released to the outside via a muffler 32a that reduces the noise.

[0018] The air necessary for the combustion in the cylinders of the plurality of gas engines 1, 1, ... is filtered through an element 31b in an air cleaner 31a provided to the intake duct 31 shared by the plurality of gas engines 1, 1, ... and supplied to each gas engine 1, via the intake duct 31 and intake branch pipes 11a of the intake manifolds 11 (see FIG. 1) .

[0019] The exhaust travels from the exhaust manifolds 12 through the exhaust branch pipes 12a and exhaust duct 32, and is released to the outside via the muffler 32a that reduces the noise. Fuel is supplied from a tank (not shown) via an electromagnetic shut-off valve 41, and supplied to the mixer 13 of each gas engine 1 through a fuel line 4 drawn as a thick solid line, after the pressure is adjusted by a low-pressure adjusting valve 42 to substantially the same level as the atmospheric pressure (see FIG. 1).

[0020] The parallel arranged plurality of gas engine generators A, A, ... are equipped with the cooling water supply passage 51 that is the circulating flow passage of cooling water, and the oil supply passage 52 that is the circulating flow passage of oil, in their surroundings. The cooling water supply passage 51 includes an electric system cooling water pump 51a for circulating cooling water in the cooling water supply passage 51, and the oil supply passage 52 includes a system oil pump 52a for circulating oil in the oil supply passage 52 (see FIG. 1).

[0021] The gas engine 1 of each gas engine generator A is equipped with an engine water pump 15 and an engine oil pump 16. The engine water pump 15 and the engine oil pump 16 are discretely provided to each gas engine 1 (see FIG. 1). The engine water pumps 15 of all the gas engines 1 are each connected to the cooling water supply passage 51 in parallel with each other. The engine oil pumps 16 of all the gas engines 1 are each connected to the oil supply passage 52 in parallel with each other.

[0022] Cooling water to be supplied to each gas engine 1 of each of the plurality of parallel gas engine generators A, A, ... is pumped through the cooling water supply passage 51 by the system cooling water pump 51a and supplied to the engine water pump 15 of each gas engine 1. As the cooling water passes through and cools the gas engine 1, the temperature of the cooling water itself rises. The water then travels through return lines 51r of the cooling water supply passage 51, and releases heat in a radiator 51b before returning to the system cooling water pump 51a. The cooling water thus circulates in the cooling water supply passage 51 (see FIG. 1) .

[0023] When some of the gas engine generators A in the running gas engine generator system are stopped, the engine water pumps 15 of the gas engines 1, 1, ... for these generators are stopped and not running. Therefore, the cooling water travels through gaps inside the engine water pumps 15, passes through the water jackets of the gas engines 1, and exits to return lines 51r of the cooling water supply passage 51 via cooling water discharge passages.

[0024] The engine oil that lubricates various parts of the gas engines 1 is pumped up from a system oil tank 52b by the electric system oil pump 52a, filtered by an oil filter 52c, and supplied to each gas engine 1 through the oil supply passage 52 (see FIG. 1). When the engines are running, the oil is pressurized by the engine oil pump 16 commonly provided to each gas engine 1 and lubricates various parts of the gas engine 1. When some gas engines 1 are stopped in the running gas engine generator system, the oil that circulates in the oil supply passage 52 joins with the oil that came out into the return lines 52r unused, and flows back to the system oil tank 52b, as with the cooling water.

[0025] Next, a total control unit (TCU) 72 will be described. The total control unit (TCU) 72 opens the fuel shut-off valve 41 when a signal S indicates the necessity of stopping electricity or generating electricity. The low-pressure adjusting valve 42 adjusts the pressure of the fuel to the atmospheric pressure or substantially to the atmospheric pressure so that it is ready to be supplied to each gas engine 1. The TCU supplies power to the system cooling water pump 51a and the system oil pump 52a to circulate the cooling water and oil.

[0026] The total control unit (TCU) 72 determines which one or ones of the plurality of gas engines 1 should be driven, selects some gas engines 1 as required, and sends a signal to engine control units (ECU) 71 for starting up the engines. Based on this signal, the engine control unit (ECU) 71 activates a starter (not shown) to start up the gas engine 1.

[0027] The cooling water is pumped from the cooling water supply passage 51 to the water jacket in the gas engine 1 by the engine water pump 15 provided to the gas engine 1. Similarly, the oil from the oil supply passage 52 is pressurized and pumped to the parts in the gas engine 1 that need lubrication such as bearings by the engine oil pump 16 provided to the gas engine 1.

[0028] An oil overflow pipe 18a is provided to the gas engine 1 such as to protrude into the oil pan 18 inside the gas engine 1. The oil overflow pipe 18a keeps a necessary level of oil, while allowing the oil to flow out from the oil pan 18 of the gas engine 1 through the oil overflow pipe 18a into the return line 52r of the oil supply passage 52. The oil that has flowed into the return line 52r circulates again in the oil supply passage 52.

[0029] The oil level can be maintained more reliably with the oil overflow pipe rather than with a level sensor and an electromagnetic valve or an electric pump (not shown). Moreover, the configuration can be made simpler and inexpensive. The amount of oil in the oil pan 18 should be as low as possible so that the oil is replaced with the circulating oil quickly. To introduce oil from the oil supply passage 52 into the gas engine 1 for lubrication, a branch passage 100b that branches out from the oil supply passage 52 and leads to each gas engine 1 may be provided, so that oil is constantly introduced into the oil pan 18 of the gas engine 1 through the branch passage 100b and circulated by the engine oil pump 16 from the oil pan 18 to various parts in the gas engine 1 for lubrication (see FIG. 6).

[0030] Branch passages 100b are illustrated with imaginary lines (two-dot chain lines) in FIG. 1 and FIG. 6. The branch passages 100b are disposed such as to deliver oil into the oil pans 18 of the gas engines 1. A suction pipe 100a is provided inside the gas engine 1. The suction port side on one end of this suction pipe 100a is submerged in the oil accumulated in the oil pan 18, while the other end of the suction pipe 100a is connected to the engine oil pump 16, so that the oil is circulated in the gas engine 1 for lubrication by the action of the engine oil pump 16 (see FIG. 6).

[0031] Fuel is supplied to the mixer 13 as indicated by thick solid lines, where it is mixed with the air from the intake branch pipe 11a, and this gas mixture is sucked into the cylinders of the gas engine 1 from the intake manifold 11. The exhaust, that is the gas after combustion, travels from the exhaust manifold 12 through the exhaust branch pipe 12a and is guided from the exhaust duct 32 into the muffler 32a, where the noise is reduced, before being released to the outside.

[0032] The power output of the gas engine 1 is controlled by a throttle valve of the mixer 13 that is driven by a throttle actuator 14. A plurality of lines make up a signal line for transmission and reception of signals such as ignition signals between the engines and engine control units (ECUs) 71, whereby an ignition signal is sent to discrete ECUs, or conversely, information to be used for control such as engine rpm is sent from the ECUs.

[0033] Based on the signal, the engine control unit (ECU) 71 controls the rpm of the gas engine 1. At the moment of an increase in power demand or electrical load demand, the rpm of the gas engine 1 decreases due to a surge in torque demand for the gas engine 1. When this happens, the throttle is opened to increase the rpm to a required level to restore the rotation speed. The power demand is sometimes called electrical load demand. The electric power generated by the generator 2 run by the power of the gas engine 1 is converted to a direct current at a prescribed voltage by discrete inverters 6 and supplied to a total power inverter 8. The powers are summed up, and output as an alternating current with a prescribed voltage and frequency, or as a direct current with a prescribed voltage.

[0034] How gas engines 1 to be driven in response to a power demand are selected will be explained with reference to FIG. 4. Assuming that the power generation capacity of one generator is 50 kW, for example, and that the product of the power generation efficiency and the inverter efficiency is 0.909, the engine has to generate a power of 55 kW (50 kW/0.909). While it is possible to run the gas engines 1 such that all the generators are equal in output, this would mean that each gas engine 1 would be running with a low degree of throttle opening, which would result in poor thermal efficiency.

[0035] FIG. 3 shows the thermal efficiency when the throttle is opened gradually under a condition where the engine rpm and air-fuel ratio are constant. The more the throttle is opened to increase the power output, the better the thermal efficiency, because of the following: With the rpm being constant, there is no difference in friction loss whether the load is low or high. The lower the load, the higher the pumping loss, due to the increase in negative pressure in the intake manifold. Namely, the ratio of the energy of fuel effectively converted into work is reduced when the engine is run in a low load condition. The thermal efficiency of the gas engine 1 is therefore better when the degree of throttle opening is higher.

[0036] While it is advantageous to open the throttle as much as possible in terms of thermal efficiency, there is hardly any change in thermal efficiency after the degree of throttle opening has exceeded 80%. In consideration of the engine durability, it is therefore desirable to run the engine with about 80% degree of throttle opening. Here, the degree of throttle opening being zero means that the engine is idling, while 100% means that the throttle is fully opened.

[0037] Referring to FIG. 4, control of the power output by the gas engines 1 and the number of gas engines 1 in response to changes in power demand will be described. The solid lines indicate the case where the numbers of engines are switched, with the degree of opening of the throttle at 80%. The broken lines indicate the case where each engine is used up to 100% degree of throttle opening. The maximum power output by the engine is 55 kW. The number of engines is normally increased before the power output exceeds 80%, i.e., 44 kW.

[0038] For example, one gas engine 1 is driven until the power demand exceeds 40 kW, i.e., until the power output of the gas engine 1 reaches 44 kW. When the power demand rises to 70 kW, it cannot be generated by just one gas engine 1. To generate a power of 70 kW, the gas engine 1 needs to produce 70/0.909, i.e., 77 kW.

[0039] Accordingly, the second gas engine 1 is started up. This decision is made by the total control unit (TCU) 72, which then sends the command to the engine control unit (ECU) 71. The engine control unit (ECU) 71 immediately starts up the gas engine 1. Here, since the cooling water and oil that have been heated through the process of cooling the gas engine 1 that has already been running has been supplied to the stopped gas engine 1, the gas engine 1 that has been stopped can smoothly start up and produce a large power.

[0040] The gas engine that was started up first may be operated to generate 40 kW, while the gas engine that was started up second may be operated to generate 37 kW. This selection is also made by the total control unit (TCU) 72, which then sends the command to the engine control unit (ECU) 71 of each engine. For generating a total of 155 kW by the gas engines 1 together as shown in FIG. 4, all four gas engines 1 may be driven when all the gas engines 1 are to produce power of up to 80% degree of throttle opening, or three gas engines 1 may be driven if they are to be used up to 100%. Such operation should desirably be limited to a short period of time such as transient periods.

[0041] Therefore, with a set of four gas engine generators A, a power of up to 200 kW can be supplied, with a maximum power capacity of 220 kW. If the gas engine 1 is a large engine capable of generating up to 220 kW by itself, the degree of throttle opening will be reduced when outputting 30 kW, for example, resulting in poor thermal efficiency.

[0042] A plurality of units of gas engine generators A independent from each other are arranged in parallel, and one or more gas engines 1 are selected and driven in accordance with the power demand such that each gas engine 1 is run with a degree of throttle opening not greater than 80% even when the load requires a larger degree of throttle opening, whereby the gas engine generator system can be operated with a good balance of thermal efficiency and durability. Generally, oil temperature shows the same tendency as that of cooling water. Namely, when the cooling water temperature rises, so does the oil temperature.

[0043] The temperature of the cooling water affects the thermal efficiency of the gas engine 1 as shown in FIG. 5. There is a temperature range where the thermal efficiency of the gas engine 1 is highest. Oil thickens when the temperature decreases, which increases friction loss and leads to poor combustion in the cylinder. On the other hand, too high a temperature causes knocking, which has an extremely negative effect on the thermal efficiency, and can damage the engine. For a gas engine, the suitable temperature range is from 80°C to 90°C.

[0044] Cooling water at a temperature of this range or lower than this range by 3°C to 5°C is supplied to each gas engine 1, through heat dissipation using the radiator 51b. Heat dissipation is controlled by turning on and off an electric fan 51c or by adjusting its rpm, according to the commands sent from the total control unit (TCU) 72. Since the oil is circulated as described above, the oil pan 18 needs to store only a minimum amount of oil required at the initial start-up.

[0045] Since the amount of oil stored inside the gas engine 1 can be reduced to a minimum necessary, replacing the whole oil tank affects the entire oil to a lesser degree, which means maintenance work is made easier. This, of course, does not exclude the possibility of providing a drain plug to the bottom of each oil pan 18 to remove the oil completely from each engine.

[0046] To respond to a power demand of a maximum of several hundred kilowatts, it is optimal that each engine has a maximum power capacity of less than 100 kilowatts, so that a single engine will run in a high load condition when the power demand is low, and as the power demand increases, the number of engines is increased. For this, it is necessary to keep the engines that are not driven yet in an instantly operable condition.

[0047] Since generating power for the whole range of power demand by a single large engine entails poor thermal efficiency during low-load operations, it is beneficial to use a plurality of small-volume engines by design so as to make the engines run in a high-load condition even when the power demand is low. When responding to an increase in power demand that cannot be accommodated by one gas engine 1, another gas engine 1 is selected from the plurality of other gas engines 1, 1, ... and driven such that the power output by one gas engine 1 is high.

[0048] A plurality of gas engines 1, 1, ... are provided for this reason so that only some of the engines are driven when the power demand is low to generate power in an operating condition with a good thermal efficiency. A surge in electrical load demand can occur suddenly. In order to be able to respond to such an increase in power demand, the engines that are not running are kept warmed up or relatively warmed up. FIGS. 7A to 7C illustrate the running status of each gas engine generator A in the gas engine generator system, as the power demand increases from low to medium and from medium to high. When the power demand is low, one of the gas engines 1 is operated. When the power demand rises to a medium level, the second gas engine is operated. When the power demand is high, all the gas engines 1 are operated.

[0049] According to the present invention, all the gas engines 1, generators 2, and engine control units (ECUs) may be accommodated in one housing 9 as a package (see FIG. 2). The housing 9 may be equipped with the air cleaner 31a and muffler 32a, so that the air for combustion to be supplied to all the gas engines 1, 1, ... is filtered by one air cleaner 31a, and that one muffler 32a reduces the noise emitted by the exhausts from all the gas engines 1.

[0050] In this embodiment, the plurality of gas engines 1 accommodated in the housing 9 and configured as a package may each be provided with an electric engine water pump 15, an electric engine oil pump 16, an oil filter 52c, and a system oil tank 52b. As an alternative embodiment, cooling water may be supplied to all the gas engines 1 from the cooling water supply passage 51 by means of the system cooling water pump 51a alone, and oil may be supplied to all the gas engines 1 from the oil supply passage 52 by means of the system oil pump 52a alone.

[0051] The system has an integrated intake, exhaust, cooling, and lubricating system so as to improve maintenance, to reduce cost, and to facilitate packaging of a plurality of gas engine generators A, A, ... in a single housing 9. Moreover, the gas engine generator system of the present invention is equipped with a total control unit 72.

[0052] The total control unit 72 manages the operation and start/stop of the plurality of gas engines 1, 1, ... such that all the gas engines 1, 1, ... are equally chosen so that none of the gas engines 1 is disproportionately used i.e., that none of the gas engines 1 is used intensively. This prevents a specific one of the plurality of gas engines 1, 1, ... from being driven intensively for long hours, so that the service life of the gas engine generator system itself can be significantly prolonged.

[0053] According to the second aspect of the invention, each of the gas engines has an oil pan in which a minimum amount of oil necessary at start-up remains, while the system includes an independent oil tank capable of supplying oil to all of the gas engines. This improves the circularity of oil for the gas engines that are started up second and onwards with an increase in the amount of power demand during the operation of the generator system, and ensures an optimal condition for the gas engines when started up.

[0054] According to the third aspect of the invention, all the gas engines, generators, and engine control units are accommodated in a single housing as a package, with one air cleaner to filter air to be supplied for combustion to all the gas engines, and one muffler to reduce noise emitted by exhausts from all the gas engines. The generator system can be configured compactly in this way. Namely, the generator system can be designed as a unit. This will make installation of the generator system during construction work of a building even easier.

[0055] According to the fourth aspect of the invention, the plurality of sets of gas engines packaged in the housing are equipped with an electric engine water pump, an electric engine oil pump, an oil filter, and a system oil tank. The generator system can be made more compact and installable this way. According to the fifth aspect of the invention, the system includes three or more gas engines. This way, the load for each gas engine is reduced, which enables stable power generation.

A	Gas engine generator
1	Gas engine
15	Engine water pump
16	Engine oil pump
18	Oil pan
2	Generator
31a	Air cleaner
32a	Muffler
51	Cooling water supply passage
51a	System cooling water pump
52	Oil supply passage
52b	System oil tank
52c	Oil filter
71	Engine control unit (ECU)
72	Total control unit (TCU)
9	Housing

Claims

1. A gas engine generator system comprising: a plurality of gas engines, generators connected to the gas engines, a cooling water supply passage for supplying cooling water to each of the gas engines, a system cooling water pump that circulates the cooling water, and engine water pumps respectively provided to the gas engines,
the plurality of gas engines and a plurality of the engine water pumps being arranged in parallel to the cooling water supply passage,
the system cooling water pump being kept running when even one of the gas engines is running, so as to keep other engines that are stopped warmed up by the cooling water circulating in the cooling water supply passage,
at least one of the gas engines being operated at first, with remaining gas engines being run successively in accordance with an increase in power demand,
the system further comprising a total control unit (TCU),
the total control unit (TCU) sending signals to select, run, and stop the plurality of gas engines so as to run the gas engines proportionately, and
all the gas engines are controlled so as to rotate at a constant revolution number.

2. The gas engine generator system according to claim 1, wherein each of the gas engines has an oil pan in which a minimum amount of oil necessary at startup remains, while the system includes an independent oil tank capable of supplying oil to all of the gas engines.

3. The gas engine generator system according to claim 1 or 2, wherein all the gas engines, the generators, and engine control units are accommodated in a single housing as a package, the system being configured with one air cleaner to filter air to be supplied for combustion to all the gas engines, and one muffler to reduce noise emitted by exhausts from all the gas engines.

4. The gas engine generator system according to claim 3, wherein each of the plurality of gas engines in the package is equipped with an electric engine water pump, an electric engine oil pump, an oil filter, and a system oil tank.

5. The gas engine generator system according to claim 1 or 2, wherein the system includes three or more gas engines.

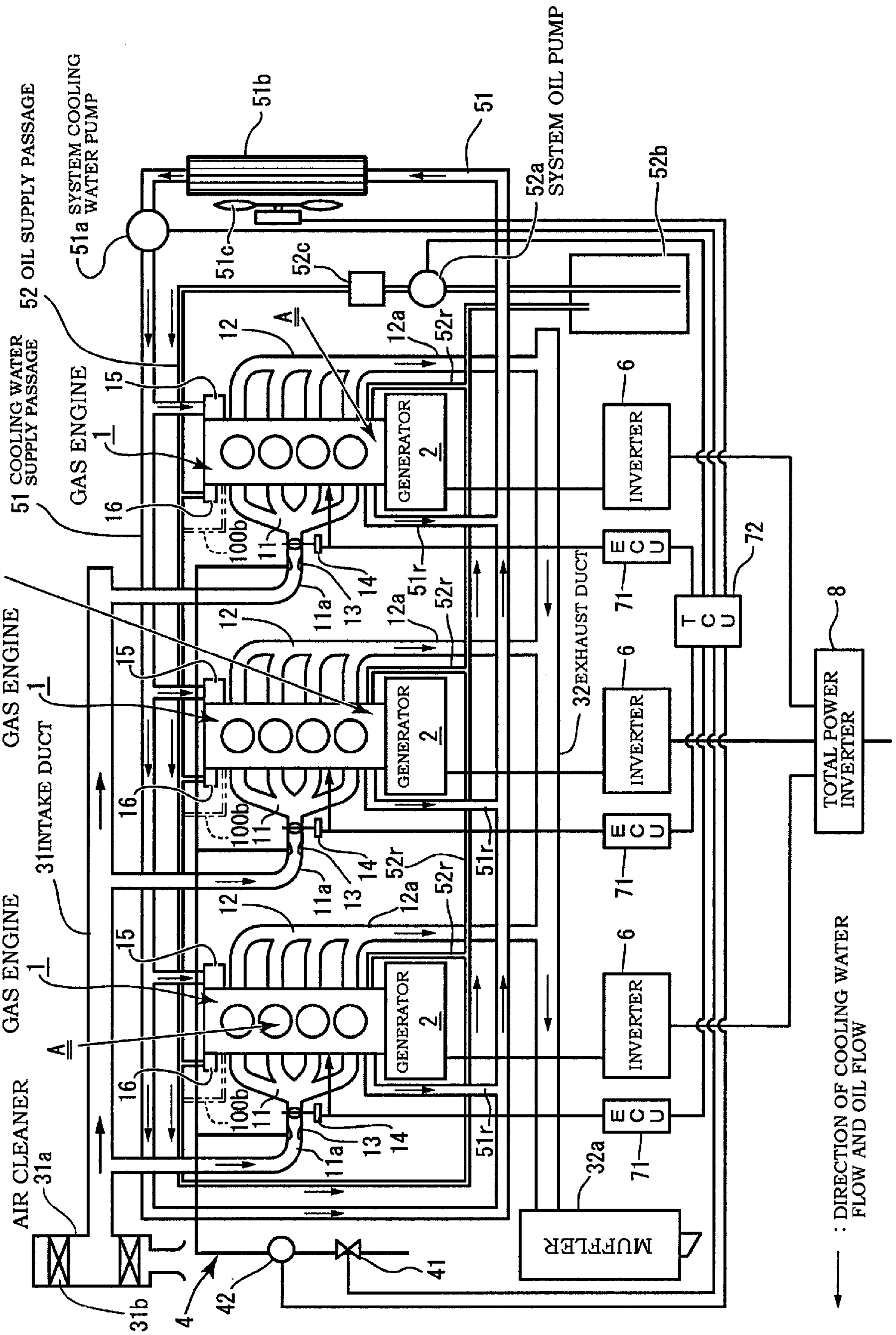
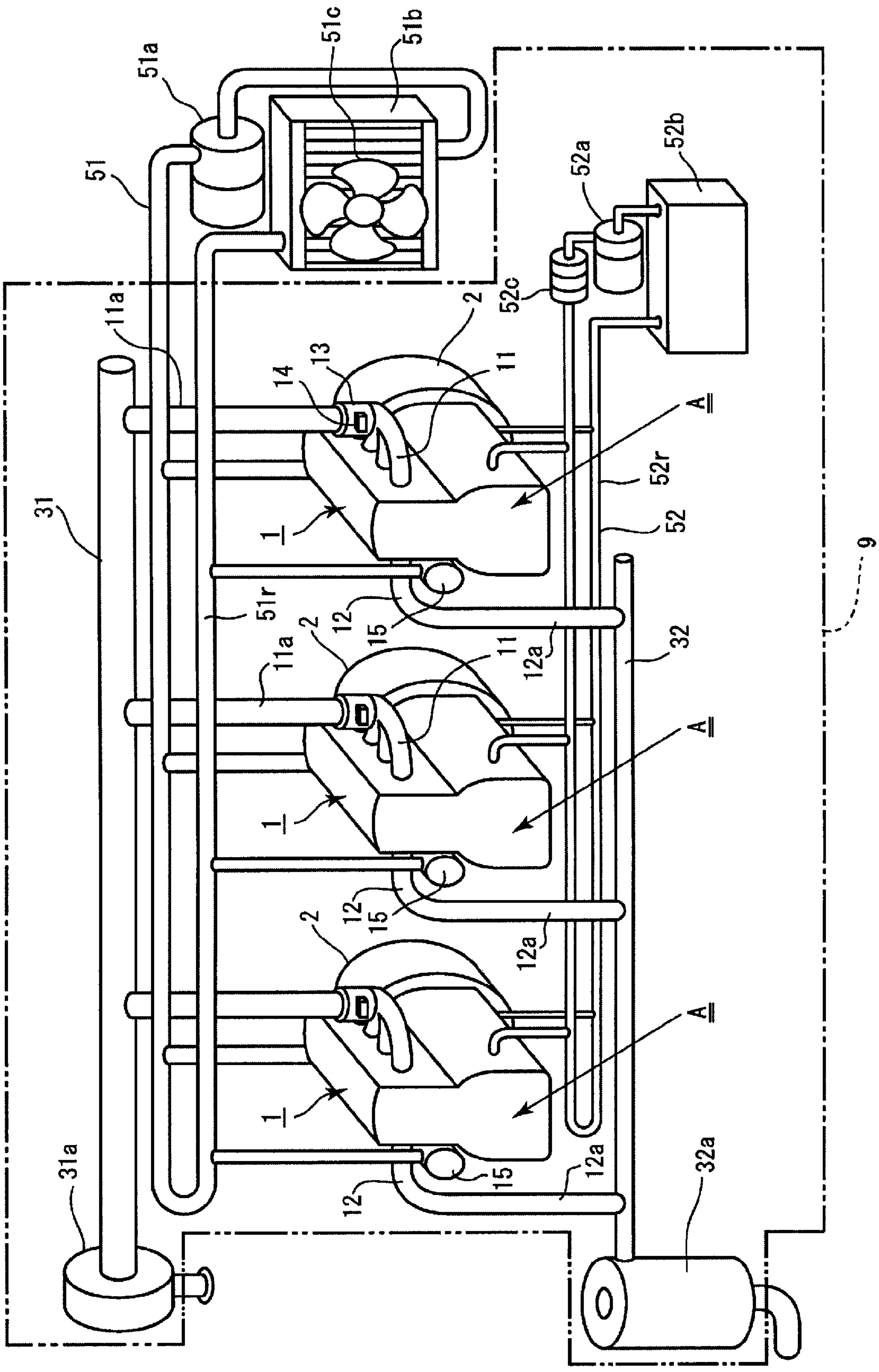
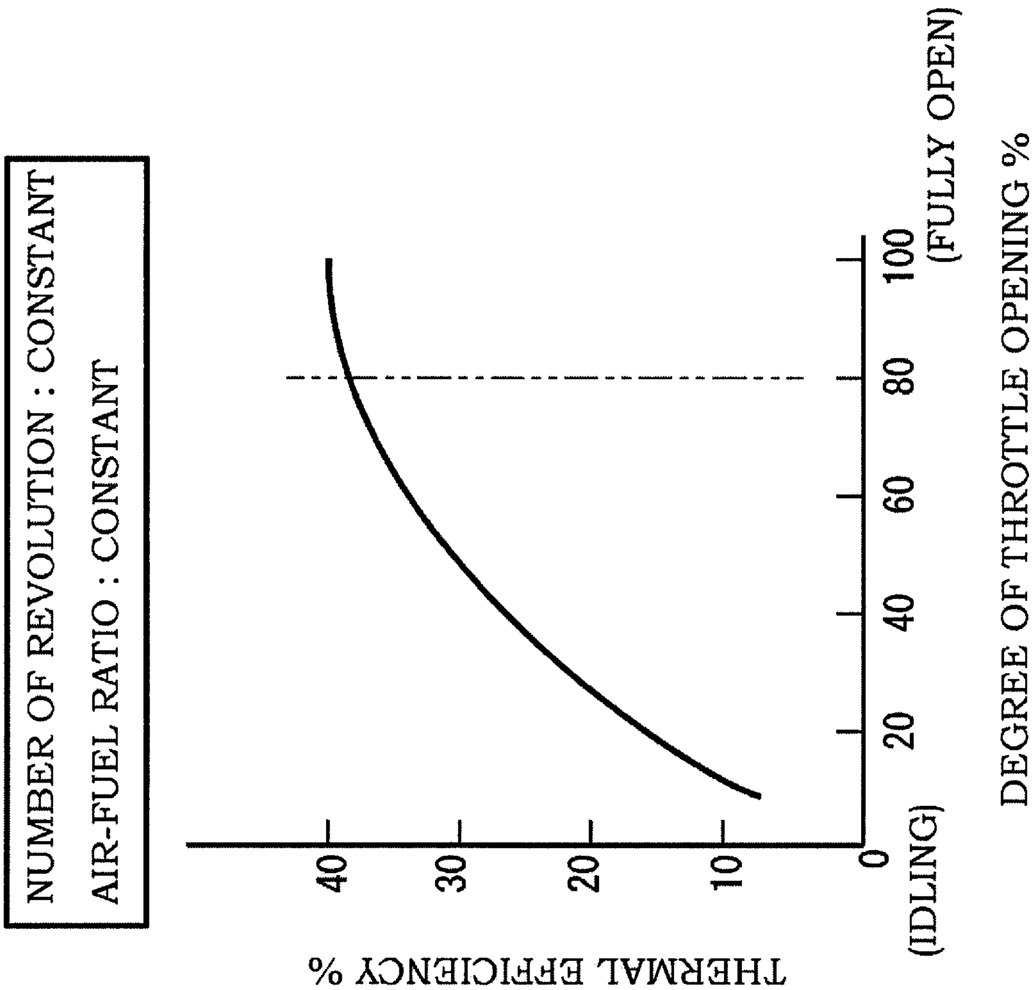

51a SYSTEM COOLING WATER PUMP
52 OIL SUPPLY PASSAGE
A GAS ENGINE GENERATOR
51 COOLING WATER SUPPLY PASSAGE
GAS ENGINE
GAS ENGINE
31 INTAKE DUCT
GAS ENGINE
AIR CLEANER
31a
31b
4
42
41
51b
51
51c
52c
52a SYSTEM OIL PUMP
52b
12
12a
52r
15
16
1
100b
11
11a
13
14
51r
GENERATOR
2
INVERTER
6
ECU
71
TCU
72
32 EXHAUST DUCT
TOTAL POWER INVERTER
8
32a
MUFFLER
: DIRECTION OF COOLING WATER FLOW AND OIL FLOW

Fig. 1

Fig.2


51a
51c
51b
51
52a
52b
52c
2
11a
14
13
11
A
31
1
52r
52
9
51r
12
15
12a
32
31a
32a



NUMBER OF REVOLUTION : CONSTANT
AIR-FUEL RATIO : CONSTANT
THERMAL EFFICIENCY %
40
30
20
10
0
(IDLING)
20
40
60
80
100
(FULLY OPEN)
DEGREE OF THROTTLE OPENING %

Fig.3

Fig.4

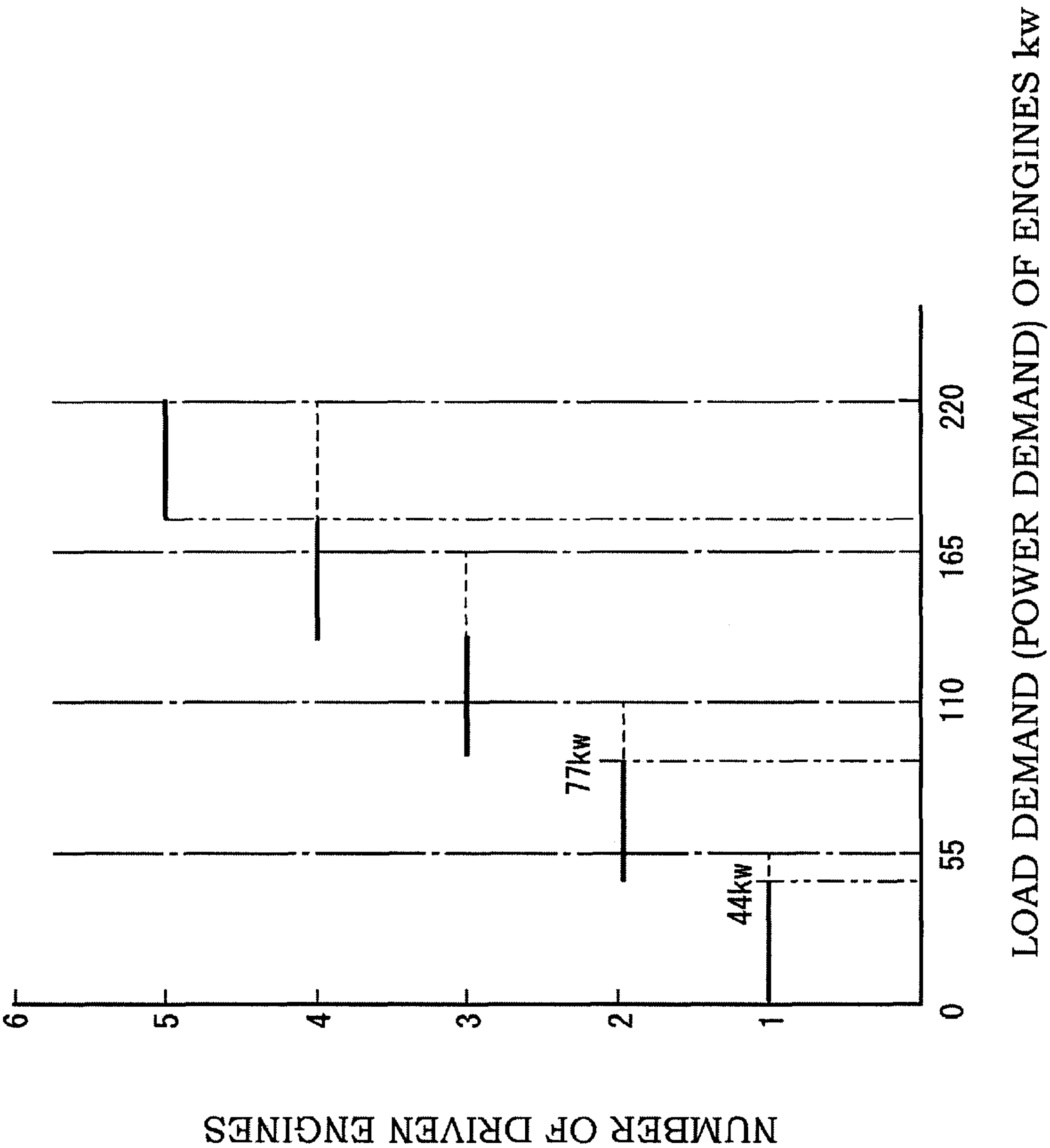

NUMBER OF DRIVEN ENGINES
LOAD DEMAND (POWER DEMAND) OF ENGINES kw
0
55
110
165
220
1
2
3
4
5
6
44kw
77kw

Fig.5

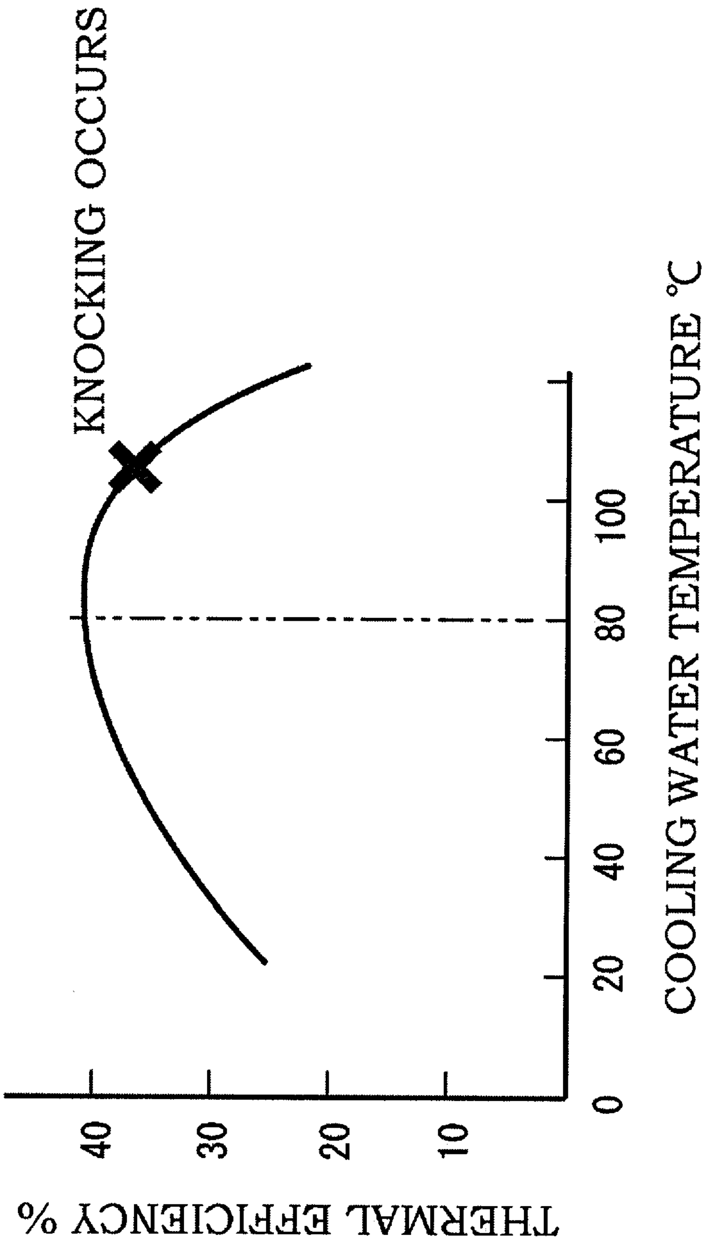

KNOCKING OCCURS
COOLING WATER TEMPERATURE °C
0
20
40
60
80
100
THERMAL EFFICIENCY %
10
20
30
40

Fig.6

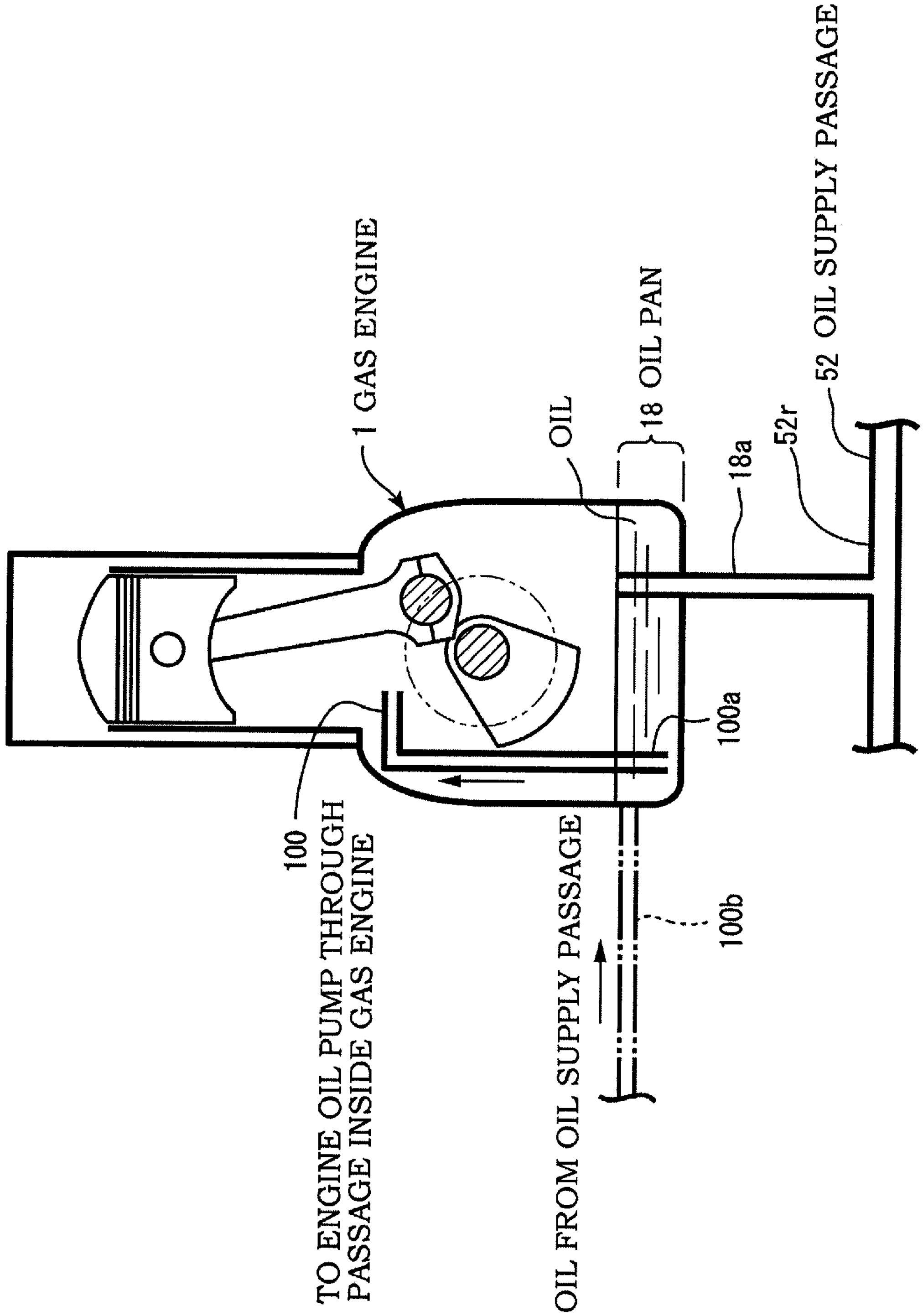

1 GAS ENGINE
OIL
18 OIL PAN
18a
52r
52 OIL SUPPLY PASSAGE
100
TO ENGINE OIL PUMP THROUGH PASSAGE INSIDE GAS ENGINE
100a
OIL FROM OIL SUPPLY PASSAGE
100b

Fig.7A

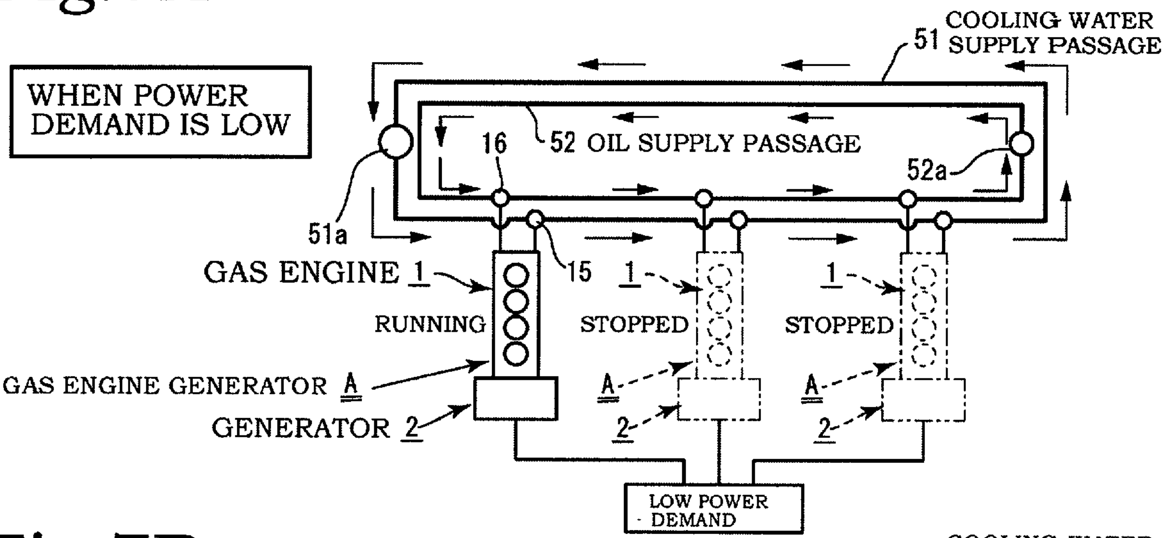


Fig.7B

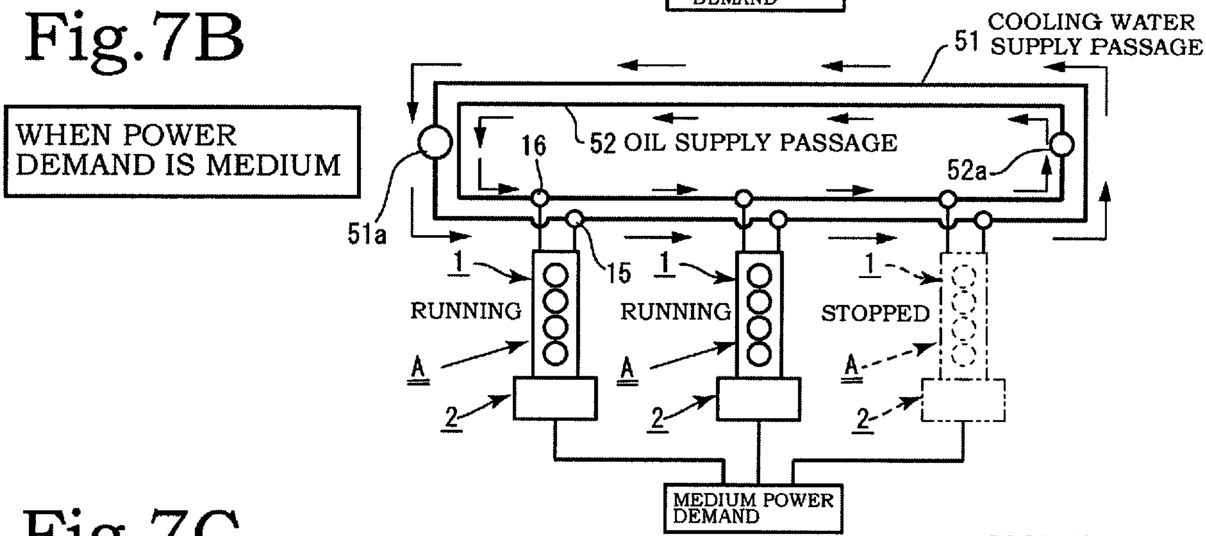
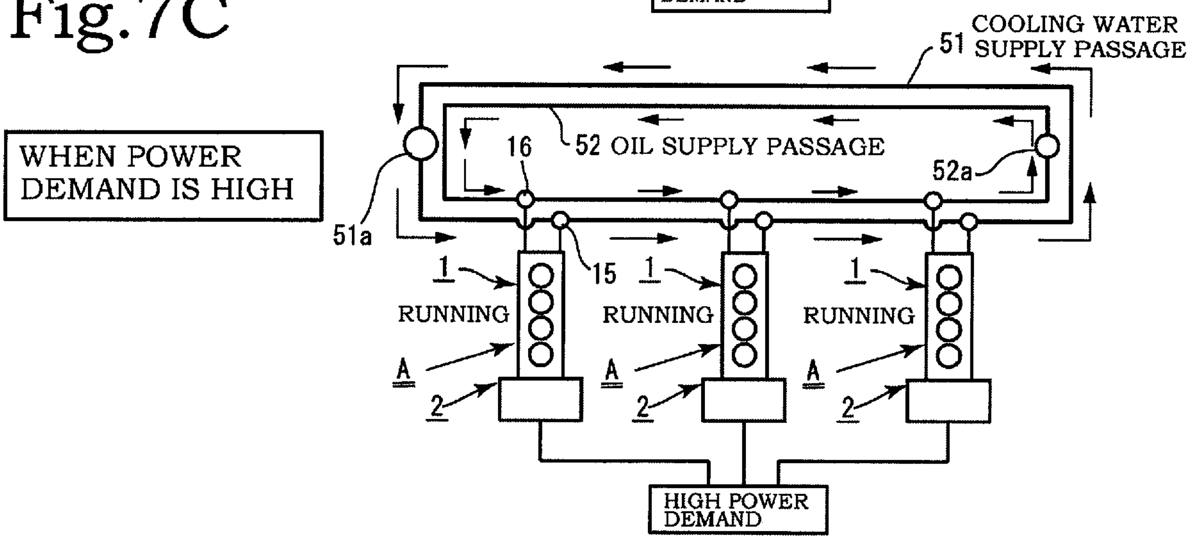


Fig.7C



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EUROPEAN SEARCH REPORT

Application Number
EP 20 16 0608

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X,P	JP 6 592212 B1 (RISE PIT CO) 16 October 2019 (2019-10-16) * claims 1-5 * -----	1-5	INV. F02D25/02 F01P11/04 F02D29/06 F02D41/00 F02N19/10 F02D25/04
X,P	GB 2 572 986 A (CATERPILLAR INC [US]) 23 October 2019 (2019-10-23) * page 10, lines 6-26 * * page 14, line 5 - page 17, line 1 * -----	1	
A	JP 2000 073861 A (HONDA MOTOR CO LTD) 7 March 2000 (2000-03-07) * abstract * -----	1-5	

TECHNICAL FIELDS SEARCHED (IPC)

F02D
F01P
F02N

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	26 June 2020	Röttger, Klaus

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26-06-2020

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