



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.12.2011 Bulletin 2011/51

(51) Int Cl.:
F01M 13/00 (2006.01)

(21) Application number: **11169809.8**

(22) Date of filing: **14.06.2011**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(72) Inventors:
• **Kobayashi, Akihiro**
Tokyo, 171-0014 (JP)
• **Mochizuki, Terumoto**
Tokyo, 171-0014 (JP)

(30) Priority: **22.12.2010 JP 2010285450**
17.06.2010 JP 2010137849

(74) Representative: **Grünecker, Kinkeldey, Stockmair & Schwanhäusser**
Leopoldstrasse 4
80802 München (DE)

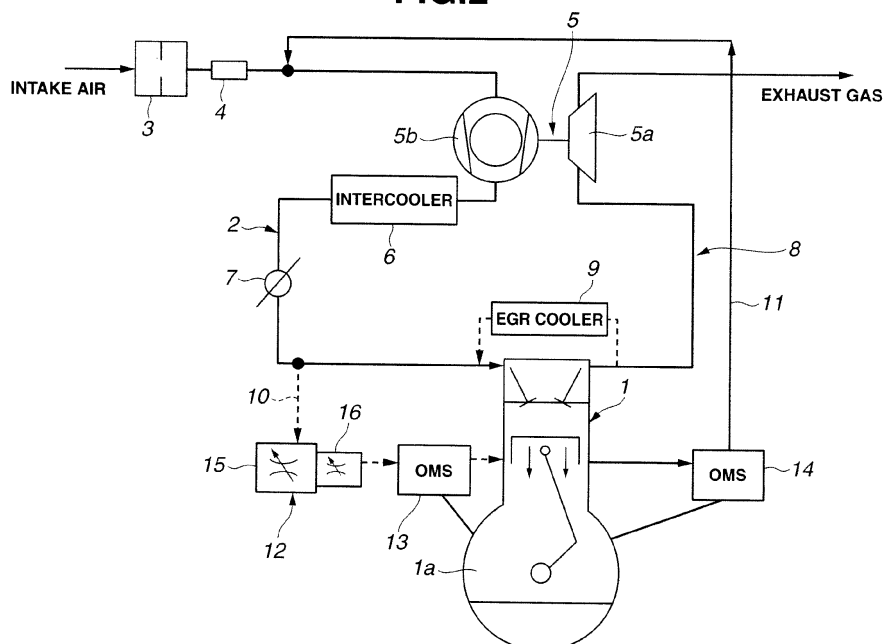
(71) Applicant: **MAHLE Filter Systems Japan Corporation**
Tokyo 171-0014 (JP)

(54) **Ventilation system and method for supercharged engine**

(57) In ventilation system and method for a supercharge engine, in a middle load driving region of the engine in which the boost pressure of position of an intake air passage located at the downstream side with respect to a throttle valve is positive and is lower than a set pressure (P1), with importance placed on the ventilation of a crank chamber, a relatively large quantity of fresh air is

introduced into the crank chamber and, on the other hand, in a high load driving region in which the boost pressure is equal to or higher than the set pressure (P1), with importance placed on the engine output, the large quantity of fresh air is supplied to the engine so that, while the deterioration of engine oil within the crank chamber suppressed, the output reduction of the engine in the high load driving region can be suppressed.

FIG.2



Description

BACKGROUND OF THE INVENTION

(1) Field of the Invention

[0001] The present invention relates to ventilation system and method for a supercharge engine having a turbocharger and particularly relates to a PCV system (a positive crankcase ventilation system) constituting a part of a blowby gas processing system.

(2) Description of related art

[0002] A Japanese Patent Application First Publication (tokkai) No. 2007-016664 published on January 25, 2007 exemplifies a first previously proposed PCV system in a natural aspiration type engine or non-supercharge type engine includes: a blowby gas reduction passage which communicates between a downstream side position of an intake air passage (intake manifold) with respect to a throttle valve and a crank chamber (or a crankcase) of the engine; a fresh air introduction passage which communicates between an upstream side of the intake manifold with respect to the throttle valve and the above-described crankcase (crank chamber); and a PCV valve installed on the above-described blowby gas reduction passage.

[0003] In the first previously proposed engine ventilation system, at a time of a high load of the engine, when a negative pressure occurs within an inside of the engine due to an action of the PCV valve, fresh air is introduced within the crank case (crank chamber) via the fresh air introduction passage and, at the same time, blowby gas is mixed with fresh air within the crank case. Then, the mixed air is introduced at position of intake air passage located at the downstream side with respect to the throttle valve via the PCV valve. In this way, the crankcase is ventilated so that a deterioration of engine oil within the crank case is suppressed.

[0004] On the other hand, at a time of a high load of the engine, the negative pressure within the intake manifold becomes reduced (approaches to the positive pressure) and the quantity of blowby gas exhausted via the PCV valve becomes less than the quantity of blowby gas generated from the engine itself. Consequently, blowby gas within the crankcase is also exhausted from the fresh air introduction passage so that fresh air is not introduced into the crankcase. Thus, engine oil within the crankcase is deteriorated due to the blowby gas.

[0005] The above-described structure is basically the same as in a case of a turbo charger equipped (supercharge) engine. Specifically, in the turbo charged engine, as compared with the natural inspiration type engine or non-supercharger engine, the pressure in the intake manifold becomes high due to an influence of the supercharge pressure. Hence, a driving region in which fresh air is not introduced into the crankcase become in-

creased. As a consequence, engine oil within the crank case becomes easy to be deteriorated due to the presence of blowby gas.

[0006] To avoid this inconvenience, the inventors have proposed a second previously proposed engine ventilation system, as disclosed in a Japanese Patent Application First Publication No. 2010-112178 published on May 20, 2010, in which an orifice for a fresh air introduction is disposed on a PCV, in the supercharge (type) engine, and fresh air is introduced within the crankcase via the PCV valve in a case where the boost pressure which is the pressure of the intake air passage indicates the positive pressure so that deterioration of engine oil within the crankcase is suppressed.

SUMMARY OF THE INVENTION

[0007] However, although, in a technique disclosed in the second previously proposed engine ventilation system, in a case where the boost pressure indicates a positive pressure, a ventilation efficiency of the crankcase is improved by introducing fresh air within the crankcase via the PCV valve from a position of the intake air passage which is located at the downstream side with respect to the throttle valve, a flow quantity of fresh air introduced into the crank chamber (crankcase) is not positively controlled and there is still a room of improvement.

[0008] It is, hence, an object of the present invention to provide ventilation system and method for the engine, especially, for the supercharge engine in which quantity of fresh air is appropriate for a present engine driving state in accordance with a driving state of the engine when the boost pressure of the intake air passage indicating the positive pressure is introduced within the crankcase.

[0009] According to one aspect of the present invention, there is provided with a ventilation system for a supercharge engine, characterized by: a blowby gas reduction passage (10) provided for communicating position of an intake air passage (2) of the engine which is located at a downstream side with respect to a throttle valve (7) with a crank chamber (1a) of the engine (1); a fresh air introduction passage (11) provided for communicating position of the intake air passage which is located at an upstream side with respect to the throttle valve and the crank chamber; a PCV valve (12, 28, 80) provided in the blowby gas reduction passage for controlling a flow quantity of blowby gas directed toward the intake air passage side in a case where a boost pressure at position of intake air passage located at downstream side with respect to the throttle valve indicates negative; and fresh air flow quantity control means (16, 29, 130, 160) for operatively introducing fresh air into the crank chamber from position of intake air passage which is located at the downstream side with respect to the throttle valve (7) in a case where the boost pressure at position of the intake air passage which is located at the downstream side with respect to the throttle valve is positive, wherein the fresh air flow

quantity control means introduces fresh air into the crank chamber, in a middle load driving region (A2) in which the boost pressure at position of the intake air passage which is located at the downstream side with respect to the throttle valve is positive and the boost pressure is lower than a set pressure (P1), and, in a high load driving region in which the boost pressure at part of the intake air passage which is located at the downstream side with respect to the throttle valve is equal to or higher than the set pressure, stops an introduction of fresh air from position of the intake air passage which is located at a downstream side with respect to the throttle valve or makes a flow quantity of introduced fresh air at least smaller than a maximum flow quantity in the middle load driving region.

[0010] According to another aspect of the present invention, there is provided with a ventilation method for a supercharge engine, characterized by: providing a blowby gas reduction passage (10) for communicating position of an intake air passage (2) of the engine which is located at a downstream side with respect to a throttle valve (7) with a crank chamber (1a) of the engine (1); providing a fresh air introduction passage (11) provided for communicating position of the intake air passage which is located at an upstream side with respect to the throttle valve and the crank chamber; providing a PCV valve (12, 28, 80) in the blowby gas reduction passage for controlling a flow quantity of blowby gas directed toward the intake air passage side in a case where a boost pressure at position of intake air passage located at the downstream side with respect to the throttle valve indicates negative; and providing fresh air flow quantity control means (16, 29, 130, 160) for operatively introducing fresh air into the crank chamber from position of intake air passage which is located at the downstream side with respect to the throttle valve (7) in a case where the boost pressure at position of the intake air passage which is located at the downstream side with respect to the throttle valve is positive, wherein fresh air is introduced into the crank chamber through fresh air flow quantity control means, in a middle load driving region (A2) in which the boost pressure at position of the intake air passage which is located at the downstream side with respect to the throttle valve is positive and the boost pressure is lower than a set pressure (P1), and, in a high load driving region in which the boost pressure at part of the intake air passage which is located at the downstream side with respect to the throttle valve is equal to or higher than the set pressure, an introduction of fresh air from position of the intake air passage which is located at a downstream side with respect to the throttle valve is stopped or a flow quantity of introduced fresh air is at least made smaller than a maximum flow quantity in the middle load driving region.

[0011] The present invention described above is based on the knowledge such that, if fresh air is introduced into the crank chamber from position of the intake air passage which is located at the downstream side with respect to the throttle valve, the quantity of fresh air sup-

plied to the engine is accordingly decreased. That is to say, in the middle load driving region, fresh air is introduced into the crank chamber from position of intake air passage which is located at the downstream side with respect to the throttle valve so that the crank chamber is positively ventilated. On the other hand, in the high load driving region requiring a high output of the engine, the introduction of fresh air into the crank chamber from position of the intake air passage which is located at the downstream side with respect to the throttle valve is stopped or a flow quantity of fresh air is made smaller than at least maximum flow quantity in the middle load driving region, in order to suppress the decrease in the fresh air quantity supplied to the engine.

[0012] According to the present invention described in the claim 1 or 7, in the middle load driving region of the engine, with importance placed on the ventilation of the crank chamber, relatively large quantity of fresh air is introduced into the crank chamber and, on the other hand, in the high load driving region, with importance placed on the engine output, the large quantity of fresh air is supplied to the engine so that, while the deterioration of engine oil within the crank chamber is suppressed, the output reduction of the engine in the high load driving region can be suppressed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Fig. 1 is a systematic view of a ventilation system for a supercharge engine in a first preferred embodiment according to the present invention and representing streams of blowby gas and fresh air in the ventilation system at a time of engine low load driving state.

[0014] Fig. 2 is a systematic view of the engine ventilation system in the first preferred embodiment according to the present invention representing the streams of blowby gas and fresh air in the ventilation system shown in Fig. 1 at a time of engine middle load driving state.

[0015] Fig. 3 is a systematic view of the engine ventilation system in the first preferred embodiment according to the present invention representing the streams of blowby gas and fresh air in the ventilation system shown in Fig. 1 at a time of engine high load driving state.

[0016] Fig. 4 is a detailed cross sectional view of a PCV valve used in the first embodiment shown in Figs. 1 through 3.

[0017] Fig. 5 is a characteristic graph representing a relationship between a boost pressure of an intake air system shown in Figs. 1 through 3 and flow quantities of blowby gas and fresh air.

[0018] Figs. 6A, 6B, and 6C are essential part expanded views representing operation states of a fresh air flow quantity control orifice shown in Fig. 4 and Figs. 6A and 6B representing operation states of the fresh air flow quantity control orifice in the middle load driving region shown in Fig. 5 and Fig. 6C representing the operation state of the fresh air flow quantity control orifice in the high load driving region shown in Fig. 5.

[0019] Fig. 7 is a systematic view of the engine ventilation system in a second preferred embodiment according to the present invention representing streams of blowby gas and fresh air at the time of the engine low load driving state.

[0020] Fig. 8 is a systematic view of the engine ventilation system in the second preferred embodiment according to the present invention representing the streams of blowby gas and fresh air in the ventilation system shown in Fig. 7 at a time of engine middle load state.

[0021] Fig. 9 is a systematic view of the engine ventilation system in the second preferred embodiment according to the present invention representing the streams of blowby gas and fresh air in the ventilation system shown in Fig. 7 at a time of engine high load driving state.

[0022] Fig. 10 is a detailed cross sectional view of the PCV valve used in the second embodiment shown in Figs. 7 through 9.

[0023] Fig. 11 is a detailed cross sectional view of a fresh air flow quantity control valve used in the second embodiment shown in Figs. 7 through 9.

[0024] Fig. 12 is a systematic view of the engine ventilation system in a third preferred embodiment according to the present invention representing streams of blowby gas and fresh air at the time of the engine low load driving state.

[0025] Fig. 13 is a detailed cross sectional view of a PCV valve used in a fourth preferred embodiment according to the present invention.

[0026] Fig. 14 is a perspective view of only a valve body of the PCV valve shown in Fig. 13.

[0027] Fig. 15 is a characteristic graph representing a relationship between a boost pressure of the intake air system in the fourth embodiment and flow quantities of blowby gas and fresh air.

[0028] Figs. 16A, 16B, and 16C are essential part expanded views representing operation states of a fresh air flow quantity control orifice shown in Fig. 13 and Figs. 16A and 16B representing operation states of the fresh air flow quantity control orifice in the middle load driving region shown in Fig. 15 and Fig. 16C representing the operation state of the fresh air flow quantity control orifice in the high load driving region shown in Fig. 5.

[0029] Fig. 17 is a perspective view of only a valve body of the PCV valve in a case of a first alternative to the fourth embodiment shown in Fig. 14.

[0030] Fig. 18 is a perspective view of only a valve body of the PCV valve in a case of a second alternative to the fourth embodiment shown in Fig. 14.

[0031] Fig. 19 is a characteristic graph representing the relationship between the boost pressure of the intake air system of the fourth embodiment and the flow quantities of the blowby gas and the fresh air in a case where the PCV valve having the valve body shown in Fig. 17 is applied.

[0032] Fig. 20 is a characteristic graph representing the relationship between the boost pressure of the intake air system of the fourth embodiment and the flow quantities of blowby gas and fresh air in a case where the PCV valve having the valve body shown in Fig. 18 is applied.

ties of blowby gas and fresh air in a case where the PCV valve having the valve body shown in Fig. 18 is applied.

[0033] Fig. 21 is a detailed cross sectional view of the fresh air flow quantity control valve in a fifth preferred embodiment of the engine ventilation system according to the present invention.

[0034] Fig. 22 is a detailed cross sectional view of the fresh air flow quantity control valve in a sixth preferred embodiment of the engine ventilation system according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

(First embodiment)

[0035] Reference will, hereinafter, be made to the drawings in order to facilitate a better understanding of the present invention. Figs. 1 through 6 show a first preferred embodiment of a ventilation system for a supercharge engine according to the present invention and, particularly, Fig. 1 represents streams of blowby gas and fresh air at a time of an engine low load driving state, Fig. 2 represents streams of blowby gas and fresh air at a time of an engine middle load driving state, and Fig. 3 represents streams of blowby gas and fresh air at a time of an engine high load driving state.

[0036] In Fig. 1, a single cylinder of a supercharge inline multi-cylinder engine is denoted by an engine 1 for a convenience purpose. In an intake air system 2 as an intake air passage, in a sequence from an upstream side of intake air system 2, an air cleaner 3, an airflow meter 4, a compressor impeller 5b of a turbo charger 5 which is a type of supercharger, an intercooler 6, and a throttle valve 7 are respectively disposed. On the other hand, a turbine impeller 5a of turbo charger 5 is intervened in an exhaust system 8 of engine 1.

[0037] Then, as is well known, intake air is passed through air cleaner 3 and airflow meter 4 and compressed (supercharged) by means of compression impeller 5b of turbo charger 5 driven by exhaust gas of engine 1. Thereafter, the compressed intake air is cooled by means of a subsequent stage of intercooler 6 and a flow quantity thereof is adjusted by means of throttle valve 7. Then, the flow quantity adjusted intake air is introduced into a combustion chamber of engine 1. It should be noted that part of exhaust gas from engine 1 is circulated into intake air system 2 via an EGR cooler 9.

[0038] Then, a blowby gas reduction passage 10 which communicates between position of intake air system 2 located at a downstream side with respect to throttle valve 7 and crankcase (or crank chamber) 1a of engine 1 is disposed and a fresh air introduction passage 11 which communicates between position of intake air system 2 located at an upstream side with respect to throttle valve 7, namely, the position of intake air system 2 which is located at the upstream side with respect to compressor impeller 5b of turbo charger 5 and crank chamber 1a of engine 1 is disposed.

[0039] PCV valve 12 and oilmist separator (OMS) 13 are serially interposed for PCV valve 12 to be in a throttle valve side 7 in blowby gas reduction passage 10. In addition, another oilmist separator (OMS) 14 is intervened for fresh air introduction passage 11. Either of oilmist separators 13, 14 is disposed independently of engine 1 and both of separators 13, 14 are installed so as to be connected with engine via hoses and so forth and both of oilmist separators 13, 14 are integrally installed together with a rocker cover (a cylinder head cover) of engine 1.

[0040] Furthermore, PCV valve 12 is provided with: a blowby gas flow quantity control orifice 15 which performs a flow quantity control function that PCV valve 12 naturally has, namely, a function to perform a control over a flow quantity of blowby gas directed toward intake air system 2 side; and a fresh air flow quantity control orifice 16 to control a flow quantity of fresh air directed toward crank chamber 1a as will be described later as fresh air flow quantity control means. In other words, while blowby gas flow quantity control orifice 15 functions as a variable orifice for a blowby gas flow quantity control, fresh air flow quantity orifice 15 functions as the variable orifice for the fresh air flow quantity control. In addition, fresh air flow quantity control orifice 16 is serially disposed at oilmist separator 13 side of the blowby gas flow quantity control orifice 15.

[0041] Fig. 4 shows the details of PCV valve 12. A spool type valve body 22 is slidably inserted within a hollow valve body 17 (casing or housing) having a stepped cylindrical shape for inner and outer peripheral surfaces thereof. Valve body 17 includes: a valve body main frame 18 in a substantially bottomed cylindrical shape; and a substantially cylindrical cover 19 connected with an opening section of valve body main frame 18. These main frame 18 and cover 19 are divided into two in an axial center direction. A first port 20 which is an opening section of cover 19 which is located at an opposing end against valve body main frame 18 which is connected with the downstream side of intake air system 2 with respect to throttle valve 7 in intake air system 2 and a second port 21 opened and formed on a bottom wall of valve body main frame 18 is connected with oilmist separator 13 side (crank chamber 1a side), respectively.

[0042] A flange section 23 is formed on an intermediate section of valve body 22 in the axial center direction of valve body 22. A first compression coil spring 26 is intervened between flange section 23 and cover 19. A second compression coil spring 27 is intervened between flange section 23 and a bottom wall of valve body main frame 18. Both tips of respective compressive coil springs 26, 27 are largely separated from each other than a thickness of flange section 23. When flange section 23 is seated on one of both compressive coil springs 26, 27, a gap G is formed between flange section 23 and the other of both coil springs 26, 27. In this way, a, so-called, play is provided on valve body 22 and an elastic force of only one of both compressive coil springs 26, 27 is acted upon valve body 22. Valve body 22 is so arranged as to be in

a stable operation.

[0043] In addition, a first throat section 19a having a step section is formed on an opening section of cover 19 facing against valve body main frame 18. Position of valve body 22 which is located toward first port 22 against flange section 23 is formed as a tipped blowby gas metering section 24 having the diameter which becomes larger toward flange section 23. Then, when the boost pressure of intake air system 2 indicates negative, valve body 16 expanded according to the negative pressure of the boost pressure at intake air system 2 is slidably displaced against valve body 17. Valve body 22 comes to a stand-still at a balanced position between the boost pressure and first compressive coil spring 26. In other words, first throat section 19a and blowby gas metering section 24 are relatively displaced in accordance with a magnitude of the negative pressure so that an opening angle between first throat section 19a and blowby gas metering section 24 are relatively moved in accordance with a magnitude of the negative pressure so that the opening angle formed therebetween, namely, the flow quantity of blowby gas flowing into PCV valve 12 is variably controlled in a continuous manner.

In other words, a gap formed between first throat section 19a and blowby gas metering section 24 functions as blowby gas flow quantity control orifice 15.

[0044] On the other hand, a second port 21 formed on valve body main frame 18 is formed in a taper shape whose diameter becomes larger as it approaches to oilmist separator 13. Position of valve body 22 which is nearer to second port 21 than flange section 23 is formed as fresh air metering section 25 of a substantially stepped column shape and whose diameter becomes larger as it becomes larger in a stepwise manner.

[0045] Fresh air metering section 25 includes: a large diameter section 25a formed on a base section of fresh air metering section 25 and having a larger diameter than a second throat section 18a which is a minimum diameter section of second port 21; a middle diameter section 25b having a smaller diameter than second throat section 25b; and a taper section 25d formed between middle diameter section 25b and smaller diameter section 25c and whose diameter becomes gradually small toward small diameter section 25c.

[0046] Then, if the boost pressure at intake air system 2 indicates positive pressure, valve body 16 pressed by means of the positive pressure is slidably displaced and comes to the stand-still. Thus, the valve body becomes stand-still at the balanced position balanced between the boost pressure and the elastic force of second compressive coil spring 27. That is to say, a relative movement of second throat section 18a and fresh air metering section 25 occurs so that the opening angle formed between both elements and the flow quantity of fresh air flowing into PCV valve 12 is variably controlled in a continuous manner. In other words, the gap formed between second throat section 18a and fresh air metering section 25 functions as fresh air flow quantity control orifice 16.

[0047] Fig. 5 shows a graph representing the relationship between the boost pressure of part of intake air passage (intake air system) 2 located at the downstream side with respect to throttle valve 7 and the flow quantity of blowby gas and so forth. A sign A denotes a development quantity of blowby gas, a sign B denotes a flow quantity characteristic of blowby gas in oilmist separator 13 at blowby gas reduction passage 10, and a sign C denotes a flow quantity characteristic of blowby gas in oilmist separator 14 at blowby gas reduction passage 11, respectively. It should be noted that the boost pressure indicates negative pressure in Fig. 5 and as the degree of negative boost pressure becomes larger, the load becomes lower (toward rightward direction in Fig. 5). Conversely, as the positive boost pressure becomes larger, the load becomes higher (toward leftward direction in Fig. 5). In addition, for the flow quantity characteristic of blowby gas denoted by signs B and C, the stream of blowby gas from crank chamber 1a to intake air system 2 indicates positive (+) and the stream of blowby gas from crank chamber 2 toward intake air system 2 indicates negative (-).

[0048] Then, in blowby gas reduction passage 10 shown in Fig. 1, PCV valve 12 is serially disposed with oilmist separator 13. Hence, the boost pressure-flow quantity characteristic of PCV valve 12 by means of both flow quantity control orifices 15, 16 provides substantially equal to the characteristic denoted by sign B in Fig. 5 and is previously adjusted.

[0049] When, in the ventilation system so constructed as described above, the magnitude of the negative pressure with the boost pressure negative is large as shown in Figs. 1 and 5, namely, in a rightmost region in Fig. 5 of engine low load driving region A1 shown in Fig. 5, valve body 22 of PCV valve 12 shown in Fig. 4 is largely stretched toward a leftward direction so that a blowby gas flow passage cross sectional area (opening angle) of blowby gas flow quantity control orifice 15 becomes relatively small. Hence, in the rightmost region of engine low load driving region A1 in Fig. 5, the blowby gas flow quantity exhausted (reduced) toward intake air system 2 through oilmist separator 13 and PCV valve 12 denoted by sign A in Fig. 5 becomes comparatively small and blowby gas development quantity itself denoted by sign A in Fig. 5 becomes small as compared with any other regions. At this time, the opening angle of fresh air flow quantity control orifice 16 becomes maximum.

[0050] Since, in this case, the blowby gas flow quantity denoted by sign B exhausted toward intake air system 2 via blowby gas reduction passage 10 is larger than the blowby gas development quantity denoted by sign A in Fig. 5, fresh air whose quantity corresponds to a difference in flow quantity of both flow quantities signed by A and B is introduced into intake air system 2 from crank chamber 1a via fresh air introduction passage 11 as denoted by sign C. While blowby gas is exhausted from crank chamber 1a to intake air system 2 via blowby gas reduction passage 10 and fresh air is introduced to crank

chamber 1a via fresh air introduction passage 11. Thus, crank chamber 1a is ventilated.

[0051] In addition, the load of engine becomes large from the above-described state and the boost pressure gradually approaches to the positive pressure. At this time, valve body 22 of PCV valve 12 in Fig. 4 is slidably displaced toward the more rightward direction than the above-described state so that a flow passage cross sectional area (opening angle) in blowby gas flow quantity control orifice 15 becomes larger than the above-described state. Thus, blowby gas flow quantity of sign B exhausted toward intake air system 2 side via blowby gas reduction passage 10 and the fresh air quantity of sign C introduced toward intake air system 2 via blowby gas introduction passage 11 are respectively increased.

[0052] Furthermore, in a positive pressure immediate prior state in which the boost pressure approaches to the positive pressure unlimitedly, the blowby gas flow quantity of sign B exhausted toward intake air system 2 via oilmist separator 13 and PCV valve 12 of blowby gas reduction passage 10 becomes less than blowby gas development quantity denoted by sign A. Then, the blowby gas is soon exhausted even from fresh air introduction passage 11 as shown in Fig. 2.

[0053] When the load of engine 1 becomes furthermore large, the boost pressure in Fig. 5 is changed to the positive pressure due to the influence of the supercharged pressure of turbo charger 5 shown in Fig. 1, valve body 22 of PCV valve 12 shown in Fig. 4 is slidably displaced toward the rightward direction in Fig. 4. As shown in Fig. 2, fresh air streamed into blowby gas reduction passage 10 due to the boost pressure from position of intake air system 2 which is located at the downstream side with respect to throttle valve 7 is reversely streamed toward crank chamber 1a via oilmist separator 13 upon the metering by means of fresh air flow quantity control orifice 16. At the same time, blowby gas developed in engine 1 is mixed with fresh air within crank chamber 1a. The mixed air is exhausted toward position of intake air system 2 which is located at the upstream side of throttle valve 7 via fresh air introduction passage 11. Thus, crank chamber 1a is ventilated. In other words, when the boost pressure is the positive pressure, the opening angle of blowby gas flow quantity control orifice 15 becomes maximum. The flow quantity of fresh air at oilmist separator 13 of blowby gas reduction passage 10 side is controlled by means of fresh air flow quantity control orifice 16 from among PCV valve 12.

[0054] Thus, the gas flow quantity in blowby gas reduction passage 10 denoted by sign B is turned to minus (-) at a middle load driving region A2 in which the boost pressure in Fig. 5 indicates positive and is smaller than a predetermined set pressure P1. It should be noted that, since the flow quantity of blowby gas exhausted toward part of intake air system 2 located at the upstream side with respect to throttle valve 7 through fresh air introduction passage 11 is a quantity which is an addition of the blowby gas development quantity denoted by sign A to

the fresh air flow quantity at blowby gas reduction passage 10, blowby gas flow quantity at fresh air introduction passage 11 denoted by sign C is in excess of the blowby gas development quantity denoted by sign A.

[0055] Figs. 6A through 6C are essential part expanded views representing operation states of PCV valve 12 when the boost pressure at part of intake air system 2 located at the downstream side with respect to throttle valve 7 is positive. In a region in which a magnitude of the positive pressure is relatively small in the middle load driving region A2 in Fig. 5, valve body 22 is slidably moved toward the rightward direction along with the increase in the boost pressure so that the flow passage cross sectional area of fresh air flow quantity control orifice 16 is gradually decreased according to taper section 25d of fresh air metering section 25. However, the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign B in Fig. 5 becomes gradually increased due to the influence of the increase in the boost pressure and soon the flow quantity thereof becomes a maximum flow quantity Q in the middle load driving region A2.

[0056] Furthermore, when the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign B in Fig. 5 is in excess of a maximum flow quantity Q and approaches to a set pressure immediate prior position at which the boost pressure approaches unlimitedly to a predetermined set pressure P1, stepped section 25e between large diameter section 25a and middle diameter section 25b is approached to a bottom wall of valve body main frame 18 so that the flow passage cross sectional area of fresh air flow control orifice 16 becomes furthermore small. Thus, the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign B in Fig. 5 and the flow quantity of blowby gas at fresh air introduction passage 11 denoted by sign C in Fig. 5 are gradually decreased along with the increase in the boost pressure.

[0057] Then, when the boost pressure has reached to predetermined set pressure P1, stepwise section 25e of fresh air metering section 25 is seated on the bottom wall of valve body 17, as shown in Fig. 6C, so that fresh air flow quantity control orifice 16 is in a complete closure state. Thus, as shown in Fig. 3 in addition to Fig. 5, in a high load driving region A3 in which the boost pressure is equal to or higher than predetermined set pressure P1, the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign B is substantially zeroed or extremely small and fresh air which has been introduced into crank chamber 1a in middle load driving region A2 is, in turn, supplied to engine 1. It should be noted that the flow quantity of blowby gas at fresh air introduction passage 11 side denoted by sign C in Fig. 5 becomes equal to the development quantity of blowby gas denoted by sign A.

[0058] Hence, in the first embodiment described above, importance is placed on the ventilation of crank chamber 1a in middle load driving region A2 in Fig. 5 and fresh air is positively introduced into crank chamber 1a through blowby gas reduction passage 10. On the other

hand, in high load driving region A3 requiring high output (power) by engine 1, an introduction of fresh air into crank chamber 1a through blowby gas reduction passage 10 is stopped in order to supply a large quantity of fresh air into engine 1. Thus, while the deterioration of engine oil due to blowby gas is suppressed, the reduction in the output of engine 1 can be prevented in high load driving region A3. It should be noted that predetermined set pressure P1 may appropriately be set with the balance between the engine output and a ventilation efficiency of crank chamber 1a taken into consideration.

[0059] In addition, in the first embodiment, the introduction of fresh air into crank chamber 1a through blowby gas reduction passage 10 is stopped in high load driving region A3. However, the flow quantity of fresh air introduced into crank chamber 1a at high load driving region A3 is always not needed to be substantial zero or to be extremely small. If the flow quantity of fresh air introduced into crank chamber 1a in high load driving region A3 is set to be smaller than maximum flow quantity Q in the case of middle load driving region A2, at least the output reduction of engine 1 can be suppressed. It should be noted that, in a case where importance is placed on the engine output in high load driving region A3, it goes without saying that it is desirable to be set to the boost pressure-flow quantity characteristic shown in Fig. 5.

(Second Embodiment)

[0060] Figs. 7 through 11 show a second preferred embodiment of the ventilation system for the supercharge engine according to the present invention. Fig. 7 shows the streams of blowby gas and fresh air at a time of the engine low load driving state, Fig. 9 shows the streams of blowby gas and fresh air at a time of the engine middle load driving state, and Fig. 10 shows the streams of blowby gas and fresh air at a time of the engine high load driving state. The same reference numerals as shown in Figs. 7 through 9 designate like elements shown in Figs. 1 through 3.

[0061] In the second embodiment, in place of PCV valve 12 used in the first embodiment, PCV valve 28 is adopted which controls only the exhaust quantity of blowby gas from crank chamber 1a to intake air system 2 side and fresh air flow quantity control valve 29 is juxtaposed with PCV valve 28 which controls the introduction quantity of fresh air from intake air system 2 to crank chamber 1a. That is to say, blowby gas reduction passage 10 is branched or joined from or into position of intake air system 2 which is located at the downstream side with respect to throttle valve 7 in the same way as the first embodiment. However, a bypass passage 30 is provided at the same position as described above (position of intake air system 2 which is located at the upstream side with respect to throttle valve 7). Fresh air flow quantity control valve 29 is provided in bypass passage 30. The other end of bypass passage 30 is connected with oilmist separator 13. This is a difference point in the second em-

bodiment from the first embodiment. The boost pressure-flow quantity characteristics of PCV valve 28 and fresh air flow quantity control valve 29 are previously adjusted to provide the same characteristics as those denoted by sign B shown in Fig. 5.

[0062] Fig. 10 shows the detailed structure of PCV valve 28. This PCV valve 28 includes: PCV valve 28 having the same structure as PCV valve 12 in the first embodiment (so-called, two-piece structured valve body 31); and spool type valve body 36 slidably inserted within valve body 31. First port 34 located at cover 32 of valve body 31 is connected with position of intake air system 2 which is located at a downstream side of throttle valve 7 and second port 35 of valve body main frame 33 of valve body 31 is connected with oilmist separator 13.

[0063] Valve body 36 includes a flange section 37 formed on a terminal end of valve body 36 located at second port 35 side; and a tipped blowby gas metering section 38 projected from flange section 37 toward first port 34 side. Compressive coil spring 39 interposed between flange section 37 and cover 32 is formed to bias valve body 36 toward second port 35. A blowby gas flow quantity metering section 38 of valve body 36 and throat section 32a on cover 32 are formed in the same way as those described in the first embodiment. A blowby gas flow quantity control orifice 40 which is equal to that described in the first embodiment is formed between throat section 32a and blowby gas metering section 38.

[0064] That is to say, in a case where the boost pressure within intake air system 2 is negative, valve body 36 is slidably displaced at the balanced position which is balanced between the boost pressure and the biasing force of compressive coil spring 39. The opening angle of blowby gas flow quantity control orifice 40 and the flow quantity of blowby gas streamed toward intake air system 2 side is variably controlled. On the other hand, in a case where the boost pressure of the intake air system 2 side is positive, flange section 37 of valve body 36 is seated on the bottom wall of valve body main frame 33 to close second port 35. Thus, PCV valve 28 is closed.

[0065] Fig. 11 shows the details of fresh air flow quantity control valve 29. This fresh air flow quantity control valve 29 includes, so-called, two piece structured valve body 41 of the same structure as PCV valve 28 and spool type valve body 46 slidably inserted into valve body 41. First port 44 of valve body 41 at cover 42 side is connected with position of intake air system 2 side located at the downstream side with respect to throttle valve 7 and second port 45 of valve body main frame side of valve body 41 is connected with oilmist separator 13 side.

[0066] Valve body 46 includes a flange section 47 formed on the end of valve body 46 toward first port 44 and a substantially stepped column shaped fresh air metering section 48 projected from flange section 47 to first port 44. Valve body 46 is biased toward first port 44 by means of compressive coil spring 49 intervened between flange section 47 and the bottom wall of valve body main frame 43. Then, fresh air metering section 48 of valve

body 46 has large diameter section 48a, middle diameter section 48b, small diameter section 48c, and taper section 48d in the same way as the first embodiment. Then, a fresh air flow quantity control orifice 50 is formed between throat section 43c of a minimum diameter section of second port 45 and small diameter section 48c. Throat section 43c which is the minimum diameter section is formed as the same structure in the first embodiment.

[0067] That is to say, in a case where the boost pressure at intake air system 2 side is negative, flange section 47 of valve body 46 is seated on a bottom wall section 42a of cover 42 to close second port 45 so that fresh air flow quantity control valve 29 is closed. On the other hand, in a case where the boost pressure at intake air system 2 side is positive, valve body 46 is slidably displaced at the balanced position at which the boost pressure and the biasing force of compressive coil spring 49 are balanced. Thus, the opening angle of fresh air flow quantity control orifice 50, namely, the flow quantity of fresh air flowing toward oilmist separator 13 is variably controlled. It should be noted that, in a case where the boost pressure in intake air system 2 side is positive, valve body 46 is slidably displaced at the balanced position at which the boost pressure and the biasing force of compressive coil spring 49 are balanced so that the opening angle of fresh air flow quantity control orifice 50, namely, the flow quantity of fresh air streamed toward oilmist separator 13 is variably controlled. It should be noted that a stepped section 48e between large diameter section 48a and middle diameter section 48b of fresh air metering section 48 is seated on the bottom wall of valve body main frame 43 to close second port 45 in the same way as described in the first embodiment.

[0068] As described in the second preferred embodiment, while bypass passage 30 is interrupted by means of fresh air flow quantity control valve 29 as shown in Fig. 7 in low load driving region A1 in Fig. 5 in which the boost pressure at intake air system 2 side is negative and the flow quantity of blowby gas exhausted toward intake air system 2 side is controlled by means of PCV valve 28 and blowby gas reduction passage 10 exhibits the function that the passage naturally has.

[0069] In addition, in a case where the boost pressure of intake air system 2 side is positive and the present engine driving region is in middle load driving region A2 in Fig. 5 in which the boost pressure is lower than set pressure P1, as shown in Fig. 8, blowby gas reduction passage 10 is interrupted according to PCV valve 28 and fresh air metered by means of fresh air flow quantity control valve 29 is introduced into crank chamber 1a via bypass passage 30. Thus, crank chamber 1a is positively ventilated.

[0070] Furthermore, in a case of high load driving region A3 shown in Fig. 5 in which the boost pressure at intake air system 2 side is equal to or higher than set pressure P1, bypass passage 30 is interrupted according to fresh air flow quantity control valve 29 as shown in Fig. 9 so that much fresh air is supplied to engine 1. Thus,

the output reduction of engine 1 is prevented.

[0071] Hence, according to the second preferred embodiment, the same function as in the same way as the first embodiment has been exhibited and fresh air flow quantity control valve 29 which controls the flow quantity of fresh air introduced to crank chamber 1a when the boost pressure at intake air system 2 side is positive is installed in addition to PCV valve 28. Hence, according to the second embodiment, the flow quantity of fresh air introduced into crank chamber 1a can highly accurately be controlled and can stably be controlled.

(Third Embodiment)

[0072] Fig. 12 shows a variation of the above-described second embodiment which corresponds to a third preferred embodiment according to the present invention and represents the streams of blowby gas and fresh air at a time of the engine low load driving state in the same way as Fig. 7.

[0073] In the third embodiment, bypass passage 51 having fresh air flow quantity control valve 29 is directly connected with crank chamber 1a of engine 1 not via oilmist separator 13.

[0074] It goes without saying that, in this case, the same function as the second embodiment is exhibited as described above.

(Fourth Embodiment)

[0075] Figs. 13 through 16 show a fourth preferred embodiment according to the present invention. The fourth embodiment is applicable to the ventilation system shown in Figs. 1 through 3 described in the first preferred embodiment according to the present invention. Specifically, PCV valve 80 is interposed having a different characteristic from that of PCV valve 12 in place of above-described PCV valve 12.

[0076] Fig. 13 shows the detailed structure of PCV valve 80 in the fourth preferred embodiment. It should be noted that the same reference numerals as PCV valve 12 designate the same constituents of PCV valve 12 and a duplicate explanation thereof will herein be omitted.

[0077] This PCV valve 80 has substantially the same structure as PCV valve 12. As shown in Fig. 14, fresh air metering section 81 of valve body 22 is formed on a root position of fresh air metering section 81. Fresh air metering section 81a includes: a large diameter section 81a having a larger diameter than a second throat section 18a which is a minimum diameter section of second port 21; a taper section 81b formed to be adjacent to anti-flange section 23 of large diameter section 81a and having an outer diameter to become gradually smaller as approaching toward second port 21 side; small diameter section 81c formed on a tip of fresh air metering section 81 and having the small diameter than taper section 81b; a stepwise section 81d formed between large diameter section 81a and taper section 81b; and a stepwise section

81e formed between taper section 81b and small diameter section 81c.

[0078] In a case where the boost pressure in intake air system 2 side is positive, valve body 22 pressed by means of the positive pressure is slidably displaced with respect to valve body 17 and valve body 17 comes to stand-still at the position at which the boost pressure and the spring force of second compressive coil spring 27 are balanced.

[0079] In a case where fresh air metering section 81 is formed as shown in Fig. 14, the boost pressure of part of intake air system 2 which is located at the downstream side with respect to throttle valve 7 is changed to the positive pressure and valve body 22 is slidably moved along with the increase in the boost pressure. At this time, stepwise section 81d is seated on the bottom wall of valve body main frame 18. Then, fresh air flow quantity control orifice is completely closed. It should be noted that the gap formed between second throat section 18a and fresh air metering section 81 functions as fresh air flow quantity control orifice 16 described above.

[0080] Fig. 15 shows a graph representing a relationship between the boost pressure at the downstream side of throttle valve 7 in intake air system 2 and blowby gas in a case where PCV valve 80 is applied to the ventilation system shown in Figs. 1 through 3. Sign A denotes a development quantity of blowby gas, sign B denotes a flow quantity characteristic of blow by gas in oilmist separator 14 at fresh air introduction passage 11, and sign C denotes the flow quantity characteristic of blowby gas in the oilmist separator 14 at fresh air introduction passage 11. It should be noted that, in Fig. 15, in the same way as described above with reference to Fig. 5, the boost pressure becomes negative and the magnitude thereof becomes large so to becomes approach to the rightward side, namely, low load side and, on the contrary, the boost pressure becomes positive and the magnitude thereof becomes large so as to become approach to the leftward side, namely, high load side.

In addition, for the flow quantity characteristic such as blowby gas denoted by signs B and C, the flow of blowby gas directed toward intake air system 2 side is assumed to be " positive (+) " and the flow of blowby gas directed toward crank chamber 1a from intake air system 2 side is assumed to be " negative (-) ".

[0081] Then, in blowby gas reduction passage 10, PCV valve 80 is serially disposed on oilmist separator 13. The boost pressure-flow quantity characteristic of PCV valve 80 by means of flow quantity control orifices 15, 16 is previously adjusted to provide substantially equal characteristic as the characteristic denoted by sign B in Fig. 15, in the fourth embodiment. In more details, from among the engine load driving regions in which the boost pressure of intake air system 2 side is positive, the middle load driving region indicates that the flow quantity of fresh air streamed into blowby gas reduction passage 10 from the downstream side of throttle valve 7 indicates constant regardless of the boost pressure. In the high load driving

region, fresh air metering section 101 is set so that the quantity of fresh air streamed from the downstream side of throttle valve to blowby gas reduction passage 10 becomes substantially zero or extremely small.

[0082] In such a fourth embodiment as described above, in low load driving region A1 shown in Fig. 15, as the magnitude of negative pressure of the boost pressure becomes larger, the flow passage cross sectional area (opening angle) of blowby gas flow quantity control orifice 15 becomes smaller. Hence, in the rightward region in Fig. 15 in low load driving region A1, the blowby gas flow quantity exhausted (circulated) toward intake air system 2 side becomes relatively small. The blowby gas development quantity itself denoted by a sign A in Fig. 15 becomes small as compared with any other regions. It should be noted that, at this time, the opening angle of fresh air flow quantity control orifice 16 becomes maximum.

[0083] Then, even in this case, since blowby gas flow quantity denoted by sign B exhausted toward intake air system 2 side through blowby gas reduction passage 10 is larger than blowby gas development quantity denoted by sign A in Fig. 15. As denoted by sign C, fresh air whose flow quantity corresponds to the difference in flow quantity of blowby gas development quantity denoted by sign A and blowby gas flow quantity denoted by sign B is introduced into crank chamber 1a through fresh air introduction passage 11. In this way, while blowby gas is exhausted from crank chamber 1a to intake air system 2 side via blowby gas reduction passage 10, fresh air is introduced from crank chamber 1a to intake air system 2 side. Thus, crank chamber 1a is ventilated.

[0084] In such a state as described above, the load of engine becomes large and the boost pressure gradually approaches to the positive side, valve body 22 of PCV valve 80 in Fig. 13 is slidably displaced toward the more rightward side and the flow passage cross sectional area (opening angle) in blowby gas flow quantity control orifice 15 becomes larger than the previous case (the above-described state). Thereby, blowby gas flow quantity denoted by sign B exhausted toward intake air system 2 side via blowby gas reduction passage 10 and the fresh air flow quantity denoted by sign C introduced into crank chamber 1a via fresh air introduction passage 11 are, respectively, increased.

[0085] Furthermore, in a positive pressure immediate prior state in which the boost pressure approaches to the positive pressure unlimitedly, the blowby gas flow quantity of sign B exhausted from intake air system 2 side through oilmist separator 13 of blowby gas reduction passage 10 and PCV valve 80 becomes smaller than blowby gas development quantity denoted by sign A and blowby gas is exhausted soon from fresh air introduction passage 11.

[0086] As the load of engine 1 becomes furthermore increased and the boost pressure in Fig. 15 turns to the positive pressure, valve body 22 of PCV valve 80 in Fig. 13 is slidably displaced toward the rightward direction

upon receipt of the boost pressure so that fresh air streamed into blowby gas reduction passage 10 from position of intake air system 2 which is located at downstream side with respect to throttle valve 7 is metered by means of fresh air flow quantity control orifice 16 and is reversely caused to flow toward crank chamber 1a via oilmist separator 13. At the same time, blowby gas developed in engine 1 is mixed with fresh air within crank chamber 1a and is exhausted toward part of intake air system 2 which is located at the upstream side with respect to throttle valve 7 side via fresh air introduction passage 11. Thus, crank chamber 1a becomes ventilated. In other words, when the boost pressure of PCV valve 80 is positive, the opening angle of blowby gas flow quantity control orifice 15 becomes maximum. Thus, the flow quantity of fresh air at oilmist separator 13 in blowby gas reduction passage 11 is controlled by means of fresh air flow quantity control orifice 16 of PCV valve 80.

[0087] Thus, in the driving region in which boost pressure in Fig. 15 is positive, namely, in middle driving region A in which the boost pressure is positive and is smaller than predetermined set pressure P1 and in the high load driving region in which the boost pressure is equal to or higher than predetermined set pressure P1, the gas flow quantity in blowby gas reduction passage 10 side denoted by sign B is turned to be minus (-). It should be noted that, since the flow quantity of blowby gas exhausted toward the position of intake air system 2 which is located at the upstream side with respect to throttle valve 7 via fresh air introduction passage 11 is an added value of the fresh air flow quantity at blowby gas reduction passage 10 denoted by sign B to blowby gas development quantity denoted by sign A, the blowby gas flow quantity at fresh air introduction passage 11 denoted by sign C is in excess of blowby gas development quantity denoted by sign A.

[0088] Figs. 16A through 16C are essential part expanded views representing operation state of PCV valve 80 when the boost pressure at position of intake air system 2 located at the downstream side with respect to throttle valve 7 is positive. In middle load driving region A2 in Fig. 15, valve body 22 is slidably displaced toward the rightward direction as shown in Figs. 16A and 16B along with the increase in the boost pressure and the flow passage cross sectional area of fresh air flow quantity control orifice 16 is gradually decreased. In the fourth embodiment, the boost pressure-flow quantity characteristic of PCV valve 80 is set so that the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign B in Fig. 15 provides constant flow quantity Q1 in middle load driving region A2 even when the boost pressure of position of intake air system 2 located at downstream side of throttle valve 7 becomes large when the boost pressure of position of intake air system 2 which is located at downstream side of throttle valve 7 is turned to the positive pressure.

[0089] Then, in the immediate prior position at which the boost pressure approaches to predetermined set

pressure P1 unlimitedly, stepwise section 81d between large diameter section 81a and taper section 81b approaches to the bottom wall of valve body main frame 18 so that the flow passage cross sectional area of fresh air flow quantity control orifice 16 is furthermore made small. Thus, the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign C in Fig. 15 becomes gradually decreased along with the increase in the boost pressure.

[0090] When the boost pressure has arrived at predetermined set pressure P1, stepwise section 81d of fresh air metering section 81 as shown in Fig. 16C is seated on the bottom wall of valve body 17 so that fresh air flow quantity control orifice 16 is in a full closure state. Thus, as shown in Fig. 15, in high load driving region A3 in which the boost pressure is equal to or higher than predetermined set pressure P1, the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign B becomes substantially zero or extremely small. Thus, fresh air introduced into crank chamber 1a is supplied to engine 1 in middle load driving region A2. It should be noted that, at this time, the flow quantity of blowby gas at fresh air introduction passage 11 denoted by sign C in Fig. 15 becomes equal to blowby gas development quantity denoted by sign A.

[0091] In the engine ventilation system in the fourth embodiment as described above, importance is placed on the ventilation of crank chamber 1a in the middle driving region and fresh air of constant quantity Q1 is introduced to crank chamber 1a through blowby gas reduction passage 10. In addition, in the high load driving region of engine 1, fresh air is not substantially introduced into crank chamber 1a through blowby gas reduction passage 10, thus importance is placed on the engine output so that much of fresh air can be supplied to the engine, in the region.

[0092] In a case where PCV valve 80 is applied, constant flow quantity Q1 set in middle driving region A2 may appropriately be set with the balance between the engine output and the ventilation efficiency taken into consideration.

[0093] In addition, fresh air metering section 81 of valve body 22 in PCV valve 80 in the fourth embodiment may be structured as shown in Figs. 17 and 18.

[0094] In a first alternative shown in Fig. 17, the diameter of fresh air metering section 91 of valve body 22 becomes large toward flange section 23 and fresh air metering section 91 includes first and second taper sections 91a, 91b having tips faced toward second port 21 formed in a taper shape and stepwise section 91c formed between first taper section 91a and second taper section 91b. First taper section 91a has a larger diameter than second taper section 91b.

[0095] In a case where fresh air metering section 91 is formed as shown in Fig. 17, the boost pressure of position of intake air system 2 located at the downstream side of throttle valve 7 is turned to the positive pressure. At this time, the flow quantity of fresh air flowing through

the PCV valve is controlled to be switched into two stages in accordance with the load. In the case of PCV valve in which valve body 22 having fresh air metering section 91 is equipped, the gap formed between second throat section 18a and fresh air metering section 91 functions as fresh air flow quantity control orifice 16 described above.

[0096] Fig. 19 shows a graph representing the relationship between the boost pressure at position of intake air system 2 side located at the downstream side of throttle valve 7 and the flow quantity of blowby gas in a case where the PCV valve in which valve body 22 having fresh air metering section 91 is applied to the engine ventilation system in Figs. 1 through 3.

[0097] In middle load driving region A2 in Fig. 19, the flow passage cross sectional area of fresh air flow quantity cross sectional area is gradually decreased according to second taper section 91b of fresh air metering section 91 along with the increase in the boost pressure. However, the boost pressure-flow quantity characteristic of PCV valve is set so that fresh air at blowby gas reduction passage 10 as denoted by sign B in Fig. 19 indicates constant flow quantity Q1. Then, in the immediate prior position at which the boost pressure approaches to predetermined set pressure P1 unlimitedly, stepwise section 91c approaches to the bottom wall of valve body main frame 18 so that the flow passage cross sectional area of fresh air flow quantity control orifice 16 is furthermore made small. Thus, the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign C in Fig. 19 becomes gradually decreased along with the increase in the boost pressure.

[0098] In addition, the flow passage cross sectional area of fresh air flow quantity control orifice 16 is gradually decreased by means of first taper section 91a along with the increase in the boost pressure. However, the boost pressure-flow quantity characteristic of the PCV valve is set so that fresh air at blowby gas reduction passage 10 denoted by sign B in Fig. 19 provides constant flow quantity Q2. It should be noted that constant flow quantity Q2 at high load driving region A3 is set to be smaller than constant quantity Q1 in middle load driving region A2.

[0099] Therefore, if PCV valve having valve body 22 having such a fresh air metering section 91 as described above is applied, the ventilation efficiency can be improved and the deterioration of engine oil within crank chamber 1a can be suppressed without output reduction of engine 1 at the time of high load of engine 1 although the boost pressure at the position of intake air system 2 which is located at the downstream side with respect to throttle valve 7 is positive.

[0100] It should be noted that, in a case where the PCV valve having valve body 22 having fresh air metering section 91 described above is applied, constant flow quantity Q1 set at middle load driving region A2 and constant flow quantity Q2 set at high load driving region A3 may appropriately be set with the balance between the engine output and high load driving region A3 taken into consideration.

[0101] In a second alternative of Fig. 18, fresh air metering section 101 includes: taper section 101a formed on position of valve body 22 which is located toward second port than flange section 23, having the diameter which becomes larger as taper section 101a becomes nearer to second port 21, and of a truncated cone shape; and a tip section 102b of a column shape and formed so as to have the same diameter as the tip of taper section 101a.

[0102] In the PCV valve in which valve body 22 having this fresh air metering section 101, second throat section 18a and fresh air metering section 101 are relatively displaced in accordance with the magnitude of positive pressure so that the opening angle formed by both of sections 18a and 101 are variably controlled in the continuous manner and are controlled for the flow quantity of fresh air streamed into PCV valve to be constant irrespective of the magnitude of the positive pressure. It should be noted that, in the PCV valve in which valve body 22 having this fresh air metering section 101, a gap formed between second throat section 18a and fresh air metering section 101 functions as above-described fresh air flow quantity control orifice 16.

[0103] Fig. 20 shows a graph representing the relationship between the boost pressure of position of intake air system 2 located at the downstream side with respect to throttle valve 7 and the flow quantity of blowby gas and so forth, in a case where the PCV valve in which valve body 22 having fresh air metering section 101 is equipped is applied to the ventilation system shown in Figs. 1 through 3.

[0104] In a region from high load driving region A3 to a region in Fig. 20 in which the magnitude of positive pressure is comparatively small, the flow passage cross sectional area of fresh air flow quantity control orifice 16 is gradually decreased by means of taper section 101a of fresh air flow quantity control orifice 16. It should be noted that, in this embodiment, the boost pressure - flow quantity characteristic of the PCV valve in which valve body 22 having fresh air metering section 101 is equipped is set so that the flow quantity of fresh air at blowby gas reduction passage 10 denoted by sign B in Fig. 20 indicates constant flow quantity Q1 even if the boost pressure of position of intake air system 2 located at the downstream side with respect to throttle valve 7 becomes large when the boost pressure of position of intake air system located at the downstream side with respect to throttle valve 7 becomes large when the boost pressure at the downstream side is turned to be positive pressure.

[0105] In the PCV valve in which valve body 22 having fresh air metering section 101 is equipped in the way constructed as described above, the flow passage cross sectional area of fresh air flow quantity control orifice 16 becomes smaller as the boost pressure at position of intake air system which is located at the downstream side with respect to throttle valve 7 becomes larger positive pressure. Hence, it is possible to provide constant flow quantity Q1 for fresh air quantity introduced into crank

chamber 1a via the PCV valve even if the boost pressure at the downstream side of throttle valve 7 provides a large positive pressure.

[0106] In other words, even if the boost pressure of position of intake air system 2 located at the downstream side with respect to throttle valve 7 indicates the large positive pressure, the quantity of fresh air introduced into crank chamber 1a through the PCV valve in which valve body 22 having fresh air quantity metering section 101 is equipped can provide constant. That is to say, even if the boost pressure at position of intake air system 2 located at the downstream side with respect to throttle valve 7 at the time of high load driving state of engine 1 provides the large positive pressure, fresh air quantity equal to or larger than the constant quantity is not introduced into crank chamber 1a. Hence, at the time of high load state of engine 1, the quantity of fresh air flowing into engine 1 (intake air quantity) is not decreased.

[0107] Therefore, in a state in which the boost pressure of position of intake air system 2 located at the downstream side with respect to throttle valve 7 indicates the positive pressure, the ventilation efficiency can be improved and the deterioration of engine oil within crank chamber 1a can be suppressed.

[0108] It should be noted that, in a case of the application of the PCV valve in which valve body 22 having fresh air metering section 101 is provided to the ventilation system, constant flow quantity Q1 set at middle load driving region A2 and in high load driving region A3 may appropriately be set with the balance between the engine output and the engine ventilation efficiency of crank chamber 1a taken into consideration.

(Fifth Embodiment)

[0109] Fig. 21 shows a fresh air flow quantity control valve 130 used in a fifth preferred embodiment of the engine ventilation system according to the present invention.

[0110] In the fifth embodiment, in place of PCV quantity control valve 29 described in the second embodiment, fresh air flow quantity control valve 130 which controls the introduction quantity of fresh air from intake air system 2 side to crank chamber 1a is disposed in parallel to PCV valve 28.

[0111] The boost pressure-flow quantity characteristics of PCV valve 28 and fresh air flow quantity control valve 130 are previously adjusted to be equal to the characteristic of PCV valve 80 described in the fourth embodiment or to be substantially equal to the characteristic denoted by sign B shown in Fig. 15.

[0112] Fig. 21 shows a detailed structure of fresh air flow quantity control valve 130.

This fresh air flow quantity control valve 130 includes spool type valve body 146 slidably inserted into valve body 141 having, so-called, two piece structure in the same way as above-described fresh air flow quantity control valve 29. First port 144 of valve body 141 faced toward

cover 142 is connected with position of intake air system 2 side located at the downstream side with respect to throttle valve 7 and second port 145 of valve body 141 faced toward valve body main frame 143 side is connected with oilmist separator 13 side.

[0113] Valve body 146 includes: a flange section 147 formed on an end section of valve body 146 faced toward first port 144 side and a fresh air metering section 148 in a substantially taper shape projected from flange section 147 toward second port 145 side. A compressive coil spring 149 interposed between flange section 147 and the bottom wall of valve body main frame 143 biases valve body 146 toward first port 144 side. Then, fresh air metering section 148 of valve body 146 includes: large diameter section 148a, taper section 148b, small diameter section 148c, stepwise section 148d, and a stepwise section 148e. Thus, in the same way as described above, throat section 143a is formed in the same way as the fourth embodiment which is the minimum diameter section of second port 145. Fresh air flow quantity control orifice 150 having the same structure as the fourth embodiment is formed between throat section 143a and second port 145.

[0114] In a case where the boost pressure of intake air system 2 side described above is negative, flange section 147 of valve body 146 is seated on bottom wall section 142a of cover 142 so as to close second port 145 and so that fresh air flow quantity control valve 130 is closed. On the other hand, in a case where the boost pressure at intake air system 2 side indicates positive pressure, valve body 46 is slidably displaced at the balanced position at which the boost pressure and the biasing force of compressive coil spring 149 are balanced. Then, in the middle load driving region, the quantity of fresh air streamed from position of intake air system 2 located at the downstream side with respect to throttle valve 7 to blowby gas reduction passage 10 provides the constant quantity irrespective of the boost pressure. Thus, the boost pressure-flow quantity characteristic of fresh air flow quantity control valve 130 is set so that the quantity of fresh air streamed from position of intake air system 2 located at the downstream side of throttle valve 7 becomes substantially zero or extremely small in the high load driving region.

[0115] In the fifth embodiment having the structure as described above, in the low load driving region in which the boost pressure at intake air system 2 side is negative, fresh air flow quantity control valve 130 interrupts bypass passage 30 and, on the other hand, the flow quantity of blowby gas exhausted toward intake air system 2 side is controlled by means of PCV valve 28 so that blowby gas reduction passage 10 exhibits the function that this passage naturally has.

[0116] In the middle load driving region in which the boost pressure at intake air system 2 side is positive pressure, blowby gas reduction passage 10 is interrupted by means of PCV valve 28 and fresh air of constant flow quantity Q1 metered by means of fresh air flow quantity

control valve 130 is introduced into crank chamber 1a through bypass passage 30. Thus, crank chamber 1a is positively ventilated.

[0117] Then, in the high load driving region in which the boost pressure at intake air system 2 side is positive, blowby gas reduction passage 10 is interrupted by means of PCV valve 28 and bypass passage 30 is also interrupted by means of fresh air flow quantity control valve 130.

[0118] Hence, even in the fifth embodiment, the same function as described in each of the embodiments can be exhibited. In addition, fresh air flow quantity control valve 29 is additionally installed as is different from PCV valve 28. Hence, the flow quantity of fresh air introduced into crank chamber 1a can stably be controlled with high accuracy. Especially, in the fifth preferred embodiment, in the high load driving region in which the boost pressure at the intake air system 2 side indicates positive, the quantity of fresh air streamed from the downstream side of throttle valve 7 into blowby gas reduction passage 10 is set to become substantially zero or extremely small. Hence, importance is placed on the high load driving region of the engine so that much of fresh air can be supplied to the engine.

[0119] In the fifth embodiment described above, in place of fresh air flow quantity control valve 130, it is possible to use fresh air flow quantity control valve 160 shown in Fig. 22.

(Sixth Embodiment)

[0120] Fig. 22 shows fresh air flow quantity control valve 160 used in a sixth preferred embodiment of the engine ventilation system according to the present invention.

[0121] In the sixth embodiment, the boost pressure-flow quantity characteristics of PCV valve 28 and fresh air flow quantity control valve 160 are previously adjusted to provide the characteristics of PCV valve of valve body 22 having fresh air metering section 101 and to provide the characteristic substantially equal to the characteristic of sign B shown in Fig. 20.

[0122] Fig. 22 shows a detailed structure of fresh air flow quantity control valve 160. This fresh air flow quantity control valve 160 includes spool type valve body 166 slidably inserted into valve body 161 having, so-called, two piece structure in the same way as above-described fresh air flow quantity control valve 29.

First port 164 of valve body 161 faced toward cover 162 is connected with position of intake air system 2 side located at the downstream side of intake air system 2 with respect to throttle valve 7 and second port 165 of valve body 161 faced toward valve body main frame 163 side is connected with oilmist separator 13 side.

[0123] Valve body 166 includes a flange section 167 formed on an end section of valve body 166 faced toward first port 164 side and a fresh air metering section 168 in a substantially taper shape projected from flange section

167 toward second port 165 side. A compressive coil spring 169 interposed between flange section 167 and the bottom wall of valve body main frame 163 biases valve body 166 toward first port 164 side. Then, fresh air metering section 168 of valve body 166 includes: taper section 168a; and small diameter section 168b of the column shape. Fresh air metering section 168 is formed in the same way as fresh air metering section 101 in Fig. 18. A fresh air flow quantity control orifice 170 is formed between throat section 163a which is the minimum diameter section of second port 165 and fresh air metering section 168.

[0124] In a case where the boost pressure of intake air system 2 side is negative, flange section 167 of valve body 166 is seated on bottom wall section 162a of cover 162 so as to close second port 165 and so that fresh air flow quantity control valve 160 is closed. On the other hand, in a case where the boost pressure at intake air system 2 side indicates positive pressure, valve body 166 is slidably displaced at the balanced position at which the boost pressure and the biasing force of compressive coil spring 169 are balanced. Then, the flow passage cross sectional area of fresh air flow quantity control orifice 150 becomes gradually small along with the increase in the boost pressure. Thus, the boost pressure-flow quantity characteristic of fresh air flow quantity control valve 160 is set so that the flow quantity of fresh air streamed to oilmist separator 13 side provides constant flow quantity Q1.

[0125] In the sixth embodiment having the structure as described above, in the low load driving region in which the boost pressure at intake air system 2 side is negative, fresh air flow quantity control valve 160 interrupts bypass passage 30 and, on the other hand, the flow quantity of blowby gas exhausted toward intake air system 2 side is controlled by means of PCV valve 28 so that blowby gas reduction passage 10 exhibits the function that this passage naturally has.

[0126] In addition, in the middle load driving region and in the high load driving region in which the boost pressure at intake air system 2 side indicates positive, blowby gas reduction passage 10 is interrupted by means of PCV valve 28. Then, fresh air of constant flow quantity Q1 metered by means of fresh air flow quantity control valve 160 is introduced into crank chamber 1a through bypass passage 30. Thus, crank chamber 1a is positively ventilated.

[0127] Hence, in the sixth embodiment, the action and advantage can be obtained in the same way as in the case of the fifth embodiment. In the sixth embodiment, fresh air of constant flow quantity Q1 even at high load driving region in which the boost pressure at intake air system 2 side indicates positive is introduced from position of intake air system 2 side located at downstream side with respect to throttle valve 7 into crank chamber 1a via blowby gas reduction passage 10. Hence, the ventilation efficiency at the time of the high load driving state can be improved without introduction of output reduction

of engine 1 at the time of high load and the deterioration of engine oil within crank chamber 1a can be suppressed.

[0128] In addition, even in the fifth and sixth embodiments, fresh air flow quantity control valve 110 may directly be communicated with crank chamber 1a of engine 1 not with respect to oilmist separator 13.

[0129] The effect of the present invention defined in each of claims 1 and 7 has been described above in the summary of the invention. According to the present invention described in the claim 2 in which a variable orifice functioning as the fresh air flow quantity control means is installed in the blowby gas reduction passage and, in the high load driving region, a flow passage cross sectional area of the variable orifice which functions as the fresh air flow quantity control means is at least made smaller than the flow passage cross sectional area in the middle load driving region, since fresh air is introduced into the crank chamber utilizing a known passage, it becomes advantageous in terms of simplification of structure.

[0130] According to the present invention described in the claim 3 in which the PCV valve includes a variable orifice functioning as the fresh air flow quantity control means apart from another variable orifice for a blowby gas flow quantity control that the PCV valve naturally has, since a slight improvement is added to well known PCV valve to enable the achievement in the object of the present invention, it becomes more advantageous in terms of simplification of structure.

[0131] On the other hand, according to the present invention described in the claim 4, the variable orifice which functions as the fresh air flow quantity control means is installed in addition to the PCV valve and the flow quantity introduced into the crank chamber is controlled according to the variable orifice. Thus, the flow quantity of fresh air introduced into the crank chamber can stably be controlled with high accuracy.

[0132] According to the present invention described in the claim 5, the introduction of fresh air to the crank chamber in the high load driving region is stopped so that the output reduction of the engine can effectively be suppressed.

[0133] Then, according to the present invention described in the claim 6 in which a flow quantity of fresh air from position of the intake air passage which is located at the downstream side with respect to the throttle valve to the crank chamber, in the middle load driving region (A2), is constant and, in the high load driving region (A3), the flow quantity of fresh air from position of the intake air passage which is located at the downstream side with respect to the throttle valve is made equal to the flow quantity in the middle load driving region, in a state in which the boost pressure of position of the intake air passage located at the downstream side with respect to the throttle valve indicates positive, the quantity of fresh air introduced from position of intake air passage located at the downstream side with respect to the throttle valve does not provide the constant quantity or larger. Hence,

the ventilation efficiency can be improved without introduction of engine output and the deterioration of engine oil within the crank chamber can be suppressed.

[0134] This application is based on a prior Japanese Patent Application No. 2010-285450 filed in Japan on December 22, 2010 and No. 2010-137849 filed in Japan on June 17, 2010. Although the invention has been described above by reference to certain embodiments of the invention, the invention is not limited to the embodiments described above. Modifications and variations of the embodiments described above will occur to those skilled in the art in light of the above teachings. The scope of the invention is defined with reference to the following claims.

Claims

1. A ventilation system for a supercharge engine, **characterized by:**

a blowby gas reduction passage (10) provided for communicating position of an intake air passage (2) of the engine which is located at a downstream side with respect to a throttle valve (7) with a crank chamber (1a) of the engine (1);
a fresh air introduction passage (11) provided for communicating position of the intake air passage which is located at an upstream side with respect to the throttle valve and the crank chamber;
a PCV valve (12, 28, 80) provided in the blowby gas reduction passage for controlling a flow quantity of blowby gas directed toward the intake air passage side in a case where a boost pressure at position of intake air passage located at downstream side with respect to the throttle valve indicates negative; and
fresh air flow quantity control means (16, 29, 130, 160) for operatively introducing fresh air into the crank chamber from position of intake air passage which is located at the downstream side with respect to the throttle valve (7) in a case where the boost pressure at position of the intake air passage which is located at the downstream side with respect to the throttle valve is positive,
wherein the fresh air flow quantity control means introduces fresh air into the crank chamber, in a middle load driving region (A2) in which the boost pressure at position of the intake air passage which is located at the downstream side with respect to the throttle valve is positive and the boost pressure is lower than a set pressure (P1), and, in a high load driving region in which the boost pressure at part of the intake air passage which is located at the downstream side with respect to the throttle valve is equal to or

higher than the set pressure, stops an introduction of fresh air from position of the intake air passage which is located at a downstream side with respect to the throttle valve or makes a flow quantity of introduced fresh air at least smaller than a maximum flow quantity in the middle load driving region.

2. The ventilation system for the supercharge engine as claimed in claim 1, wherein a variable orifice (16, 29, 130, 160) functioning as the fresh air flow quantity control means is installed in the blowby gas reduction passage and, in the high load driving region, a flow passage cross sectional area of the variable orifice which functions as the fresh air flow quantity control means is at least made smaller than the flow passage cross sectional area in the middle load driving region.

3. The ventilation system for the supercharge engine as claimed in claim 2, wherein the PCV valve (12, 28, 80) includes a variable orifice (16, 29, 130, 160) functioning as the fresh air flow quantity control means apart from another variable orifice (15, 40) for a blowby gas flow quantity control that the PCV valve naturally has.

4. The engine ventilation system as claimed in claim 1, wherein a variable orifice (16, 29, 130, 160) functioning as the fresh air flow quantity control means is juxtaposed to the PCV valve and, in the high load driving region, a flow passage cross sectional area of the variable orifice is made smaller than at least the flow passage cross sectional area in the middle load driving region.

5. The engine ventilation system as claimed in any one of the preceding claims 2 through 4, wherein the variable orifice (16, 29, 130, 160) functioning as the fresh air flow quantity control means is closed in the high load driving region.

6. The ventilation system for the supercharge engine as claimed in either claim 1 or 2, wherein a flow quantity of fresh air from position of the intake air passage which is located at the downstream side with respect to the throttle valve to the crank chamber, in the middle load driving region (A2), is constant and, in the high load driving region (A3), the flow quantity of fresh air from position of the intake air passage which is located at the downstream side with respect to the throttle valve is made equal to the flow quantity in the middle load driving region.

7. A ventilation method for a supercharge engine, **characterized by:**

providing a blowby gas reduction passage (10)

for communicating position of an intake air passage (2) of the engine which is located at a downstream side with respect to a throttle valve (7) with a crank chamber (1a) of the engine (1);
 providing a fresh air introduction passage (11) 5
 provided for communicating position of the intake air passage which is located at an upstream side with respect to the throttle valve and the crank chamber;
 providing a PCV valve (12, 28, 80) in the blowby 10
 gas reduction passage for controlling a flow quantity of blowby gas directed toward the intake air passage side in a case where a boost pressure at position of intake air passage located at downstream side with respect to the throttle 15
 valve indicates negative; and
 providing fresh air flow quantity control means (16, 29, 130, 160) for operatively introducing fresh air into the crank chamber from position of 20
 intake air passage which is located at the downstream side with respect to the throttle valve (7) in a case where the boost pressure at position of the intake air passage which is located at the downstream side with respect to the throttle 25
 valve is positive, wherein fresh air is introduced into the crank chamber through fresh air flow quantity control means, in a middle load driving region (A2) in which the boost pressure at position of the intake air passage which is located at the downstream side with respect to the throttle 30
 valve is positive and the boost pressure is lower than a set pressure (P1), and, in a high load driving region in which the boost pressure at part of the intake air passage which is located at the downstream side with respect to the throttle 35
 valve is equal to or higher than the set pressure, an introduction of fresh air from position of the intake air passage which is located at a downstream side with respect to the throttle 40
 valve is stopped or a flow quantity of introduced fresh air is at least made smaller than a maximum flow quantity in the middle load driving region.

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FIG.2

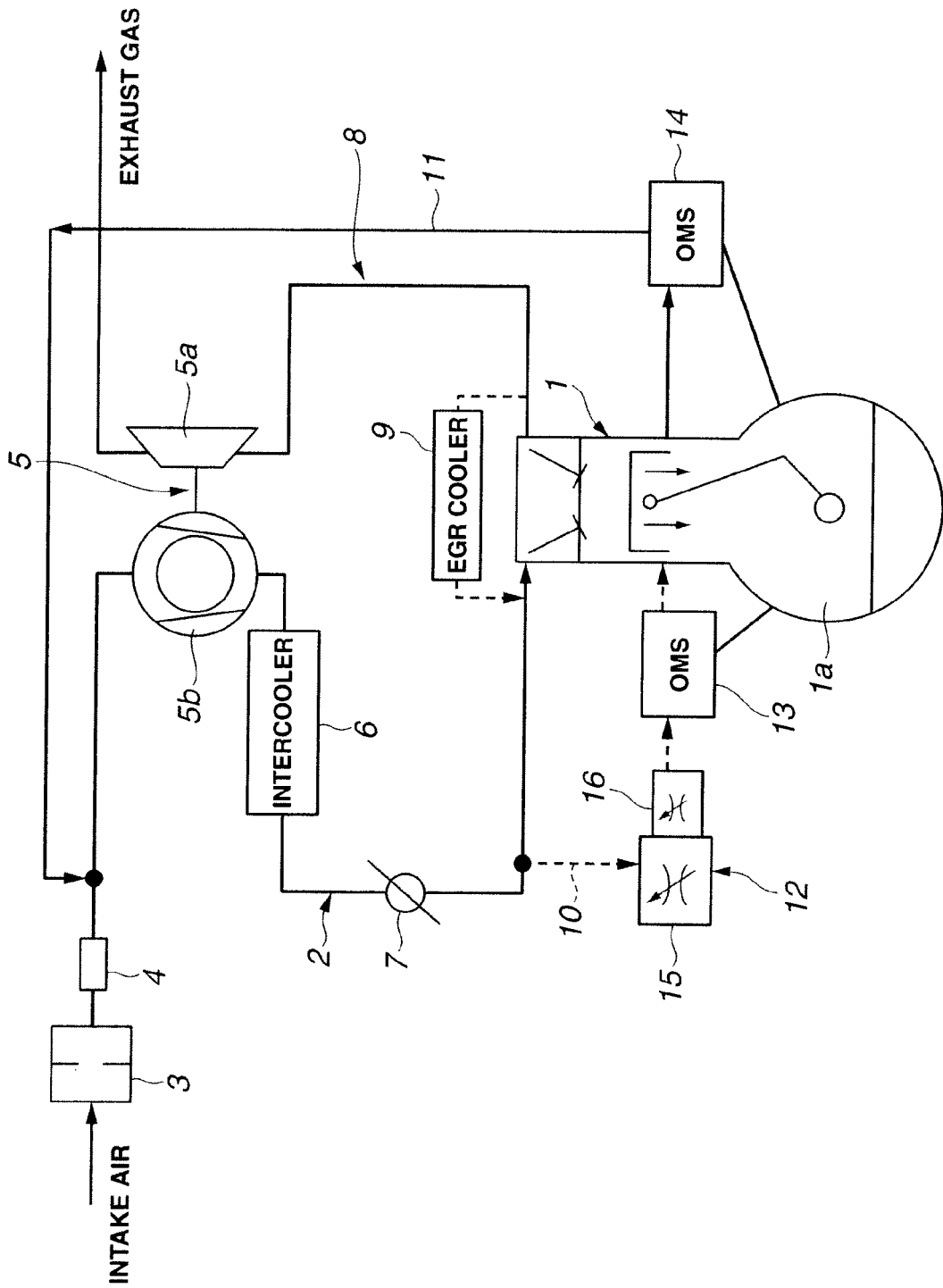


FIG.3

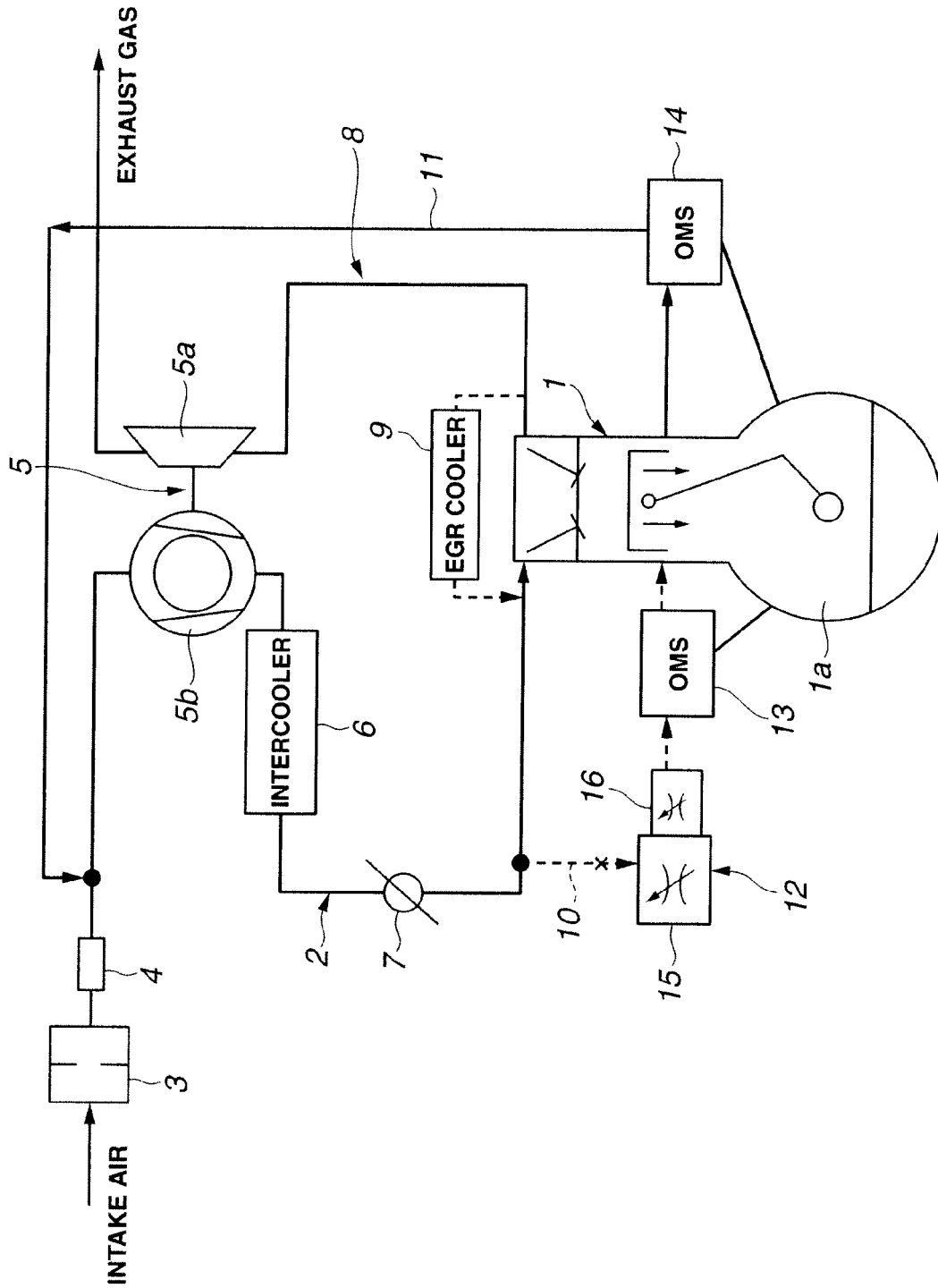


FIG. 4

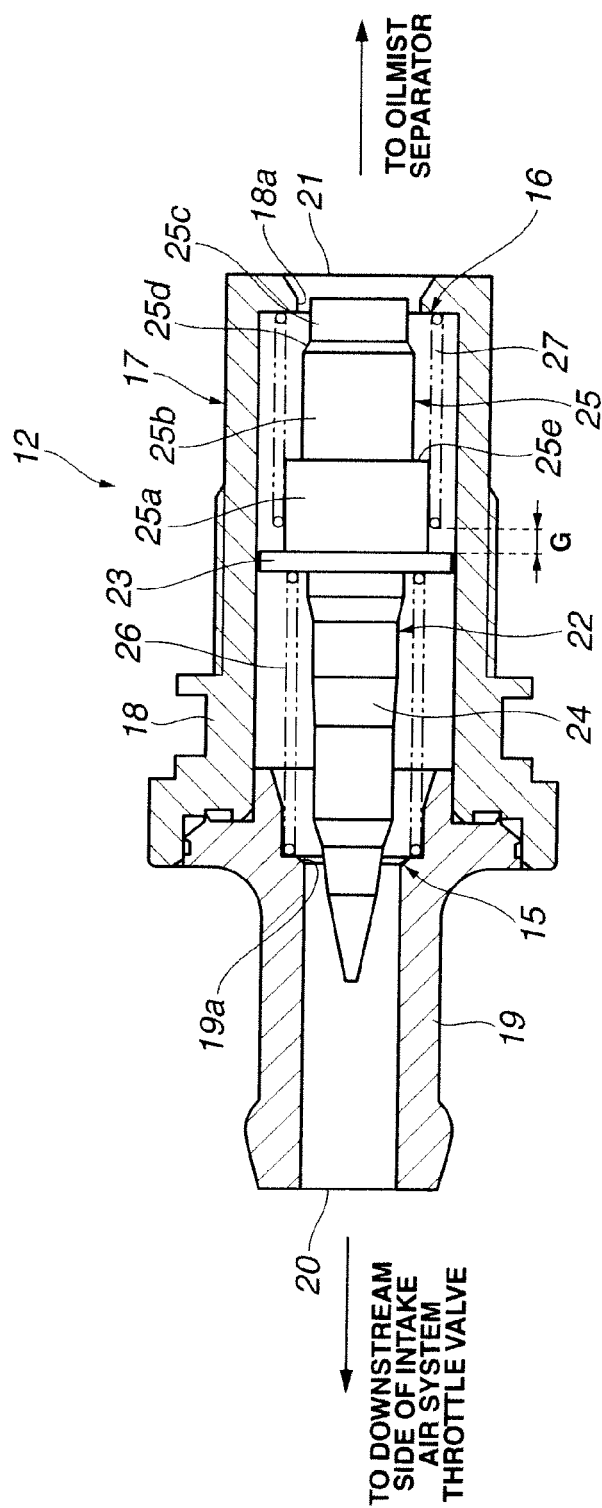


FIG.5

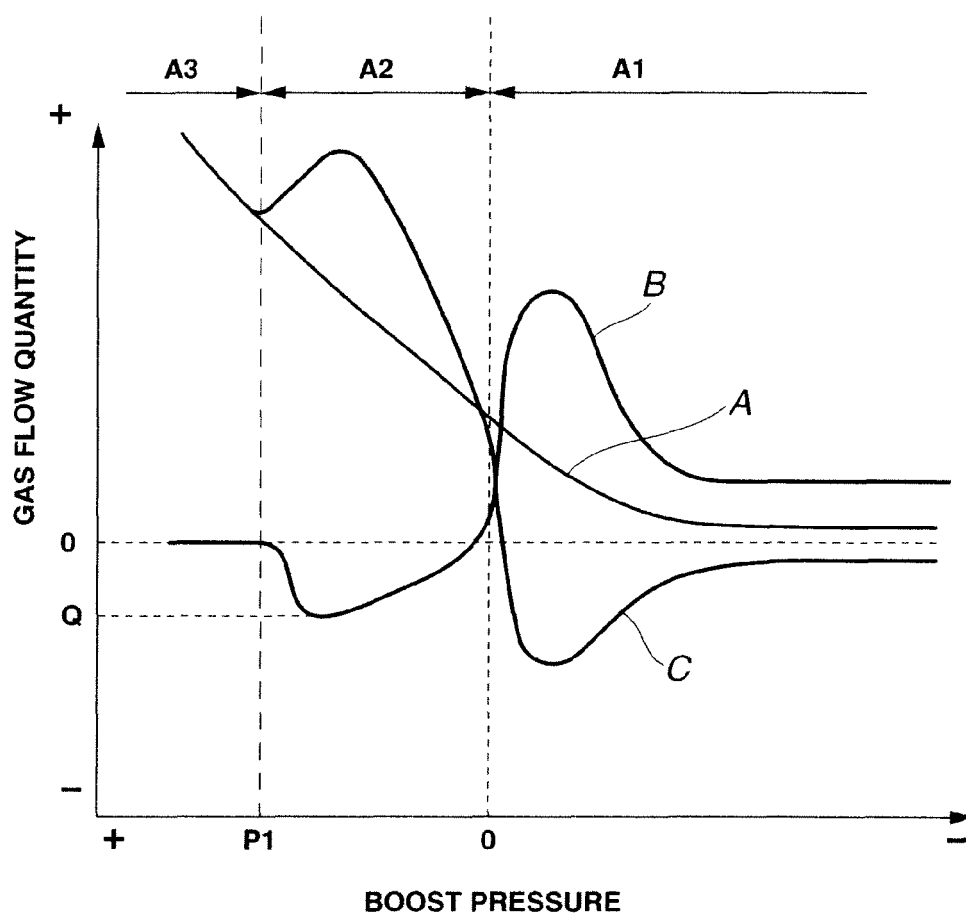


FIG.6A

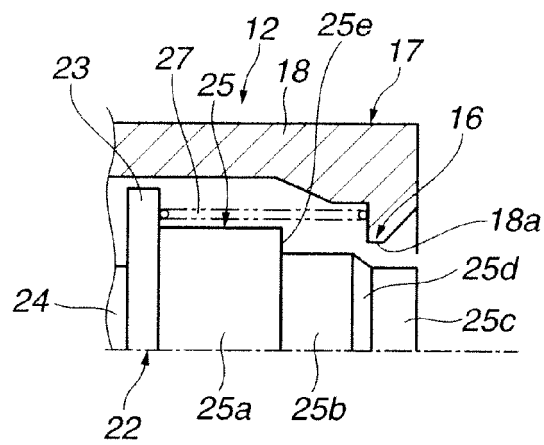


FIG.6B

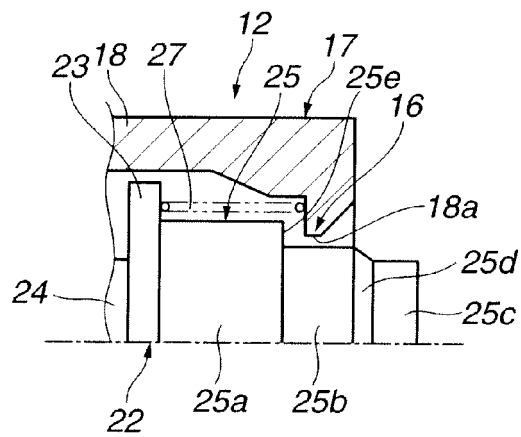


FIG.6C

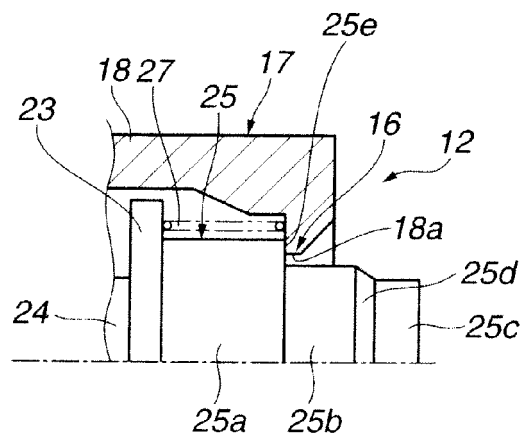


FIG.7

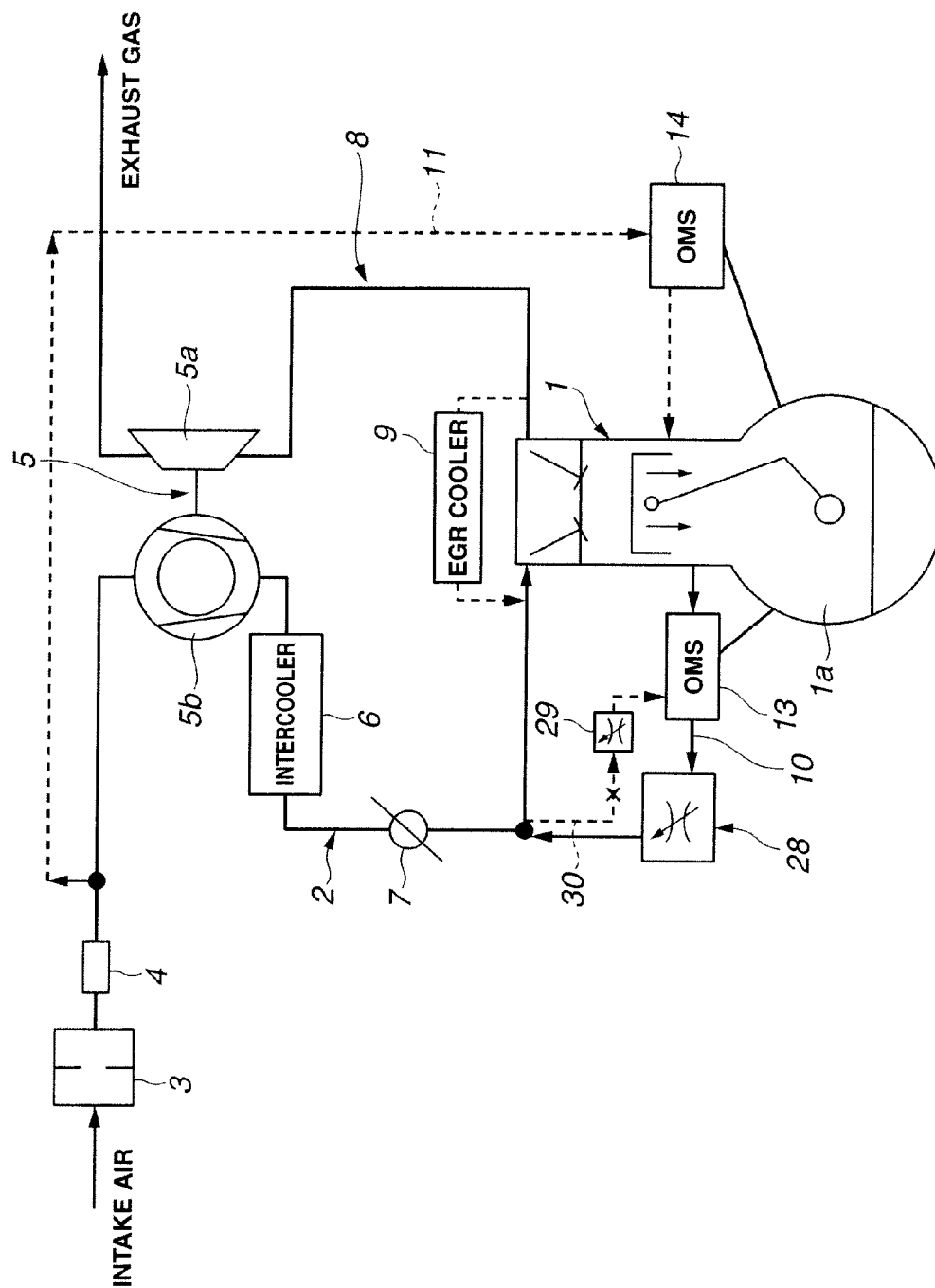


FIG.8

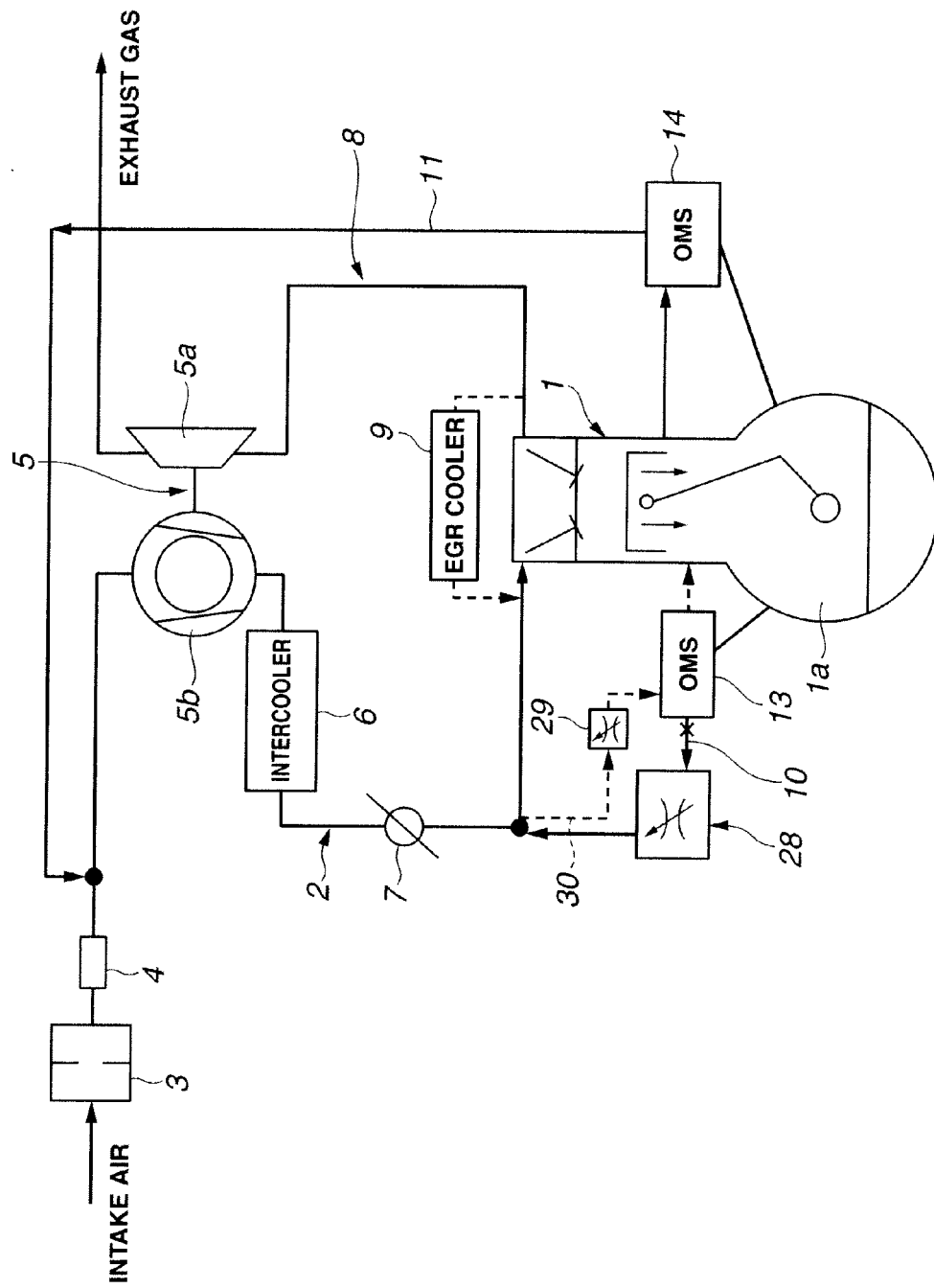


FIG.9

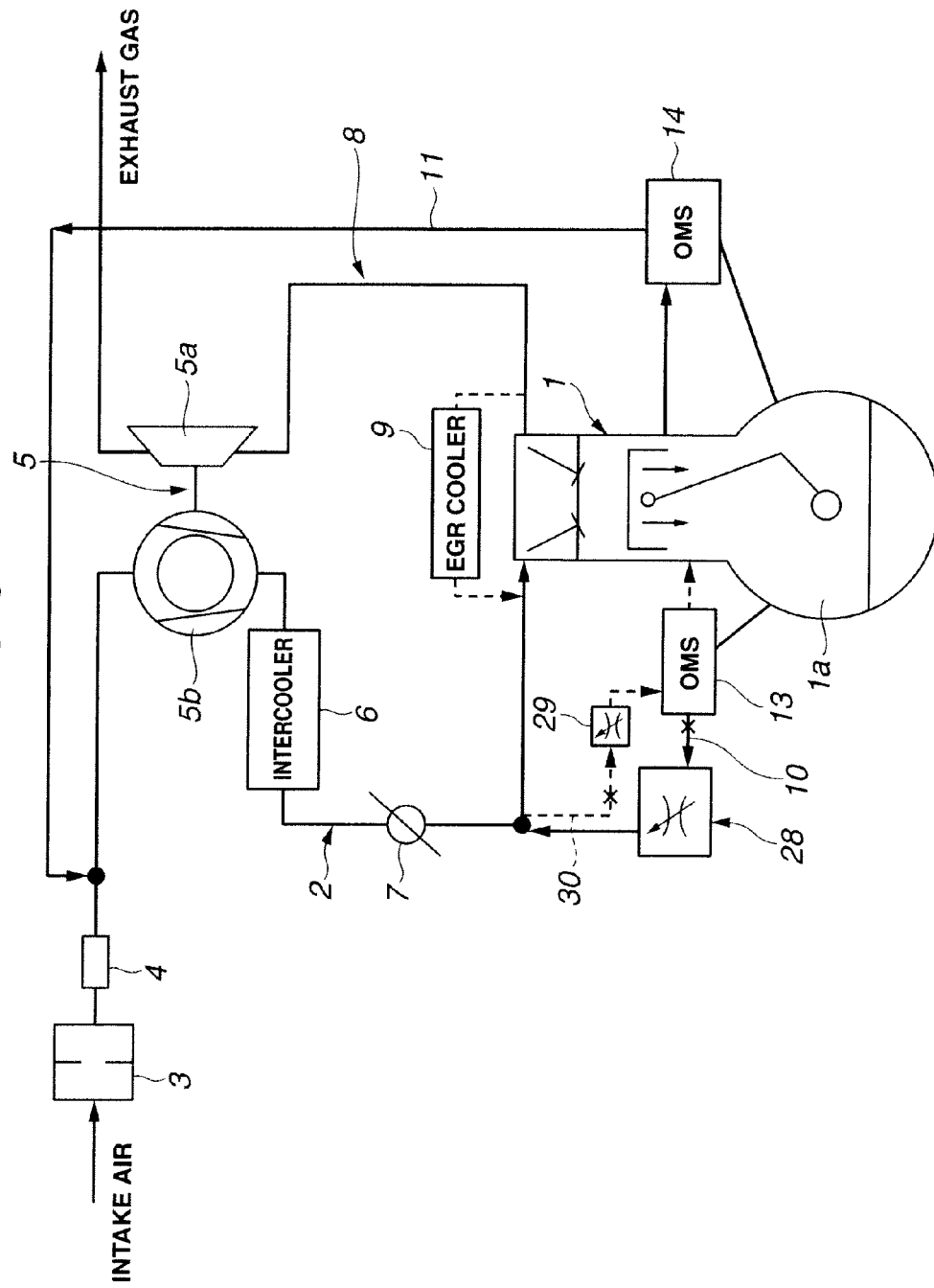


FIG.10

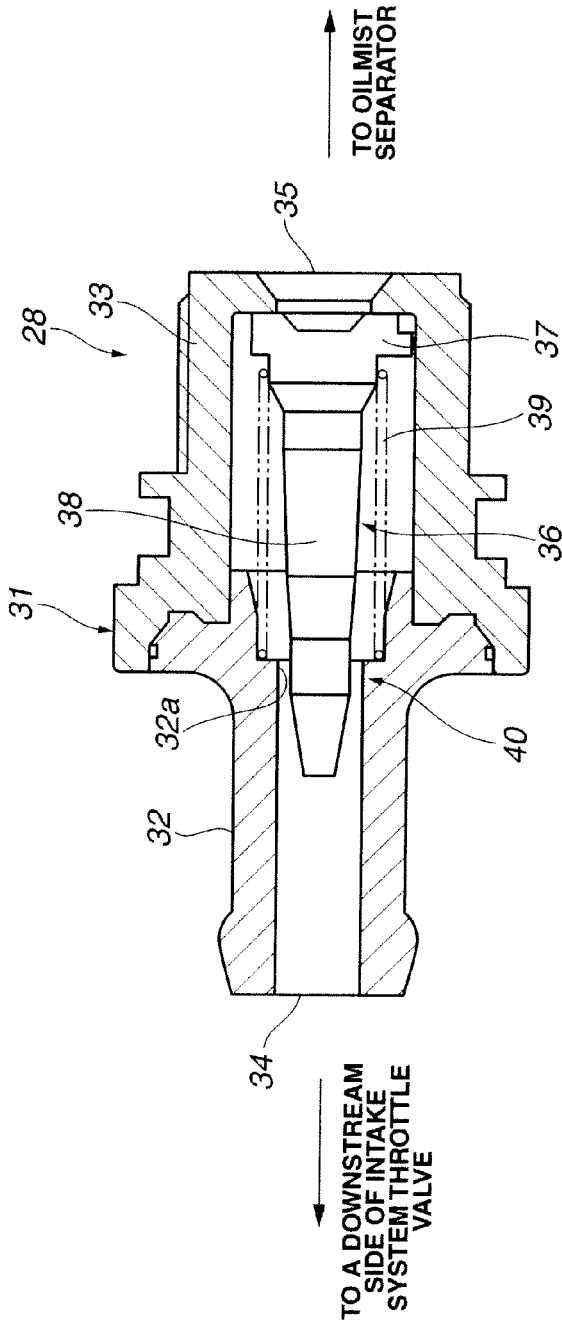


FIG.11

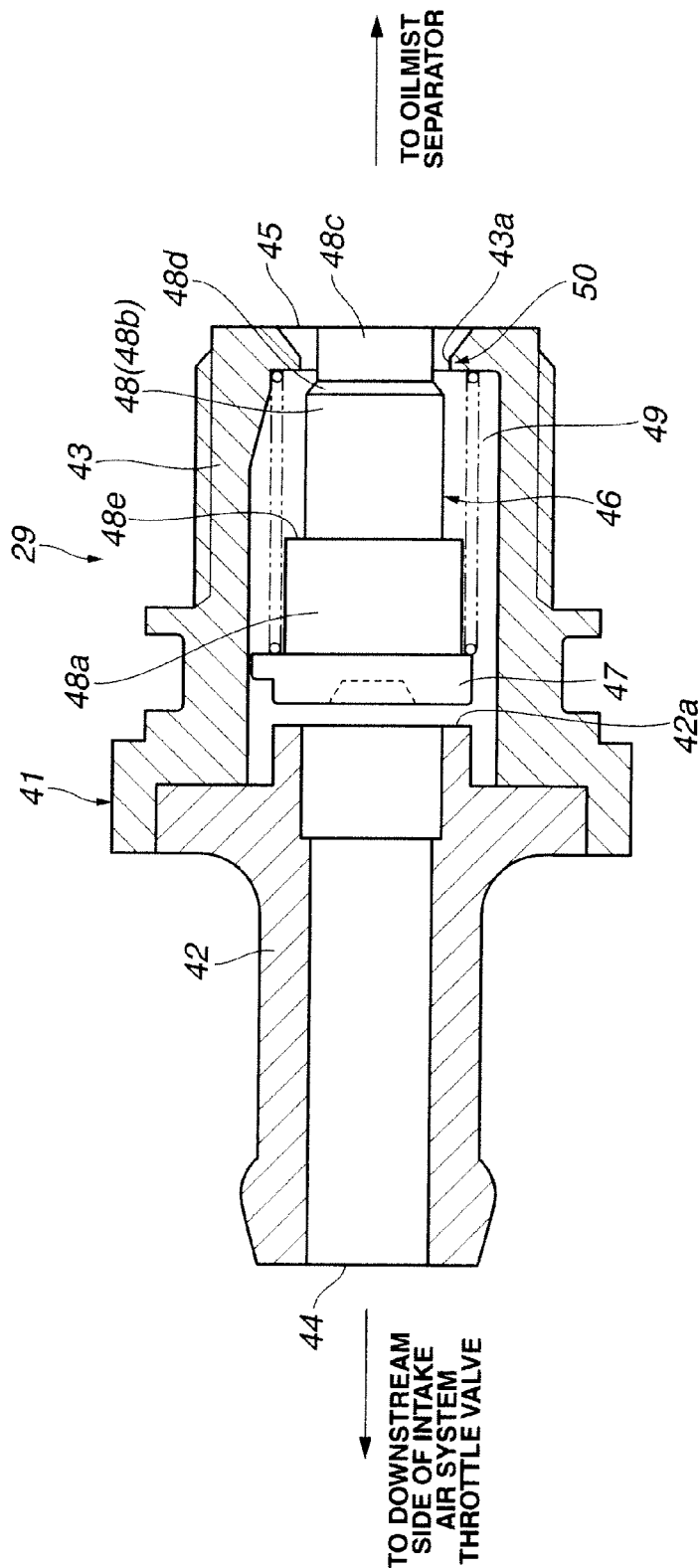


FIG.12

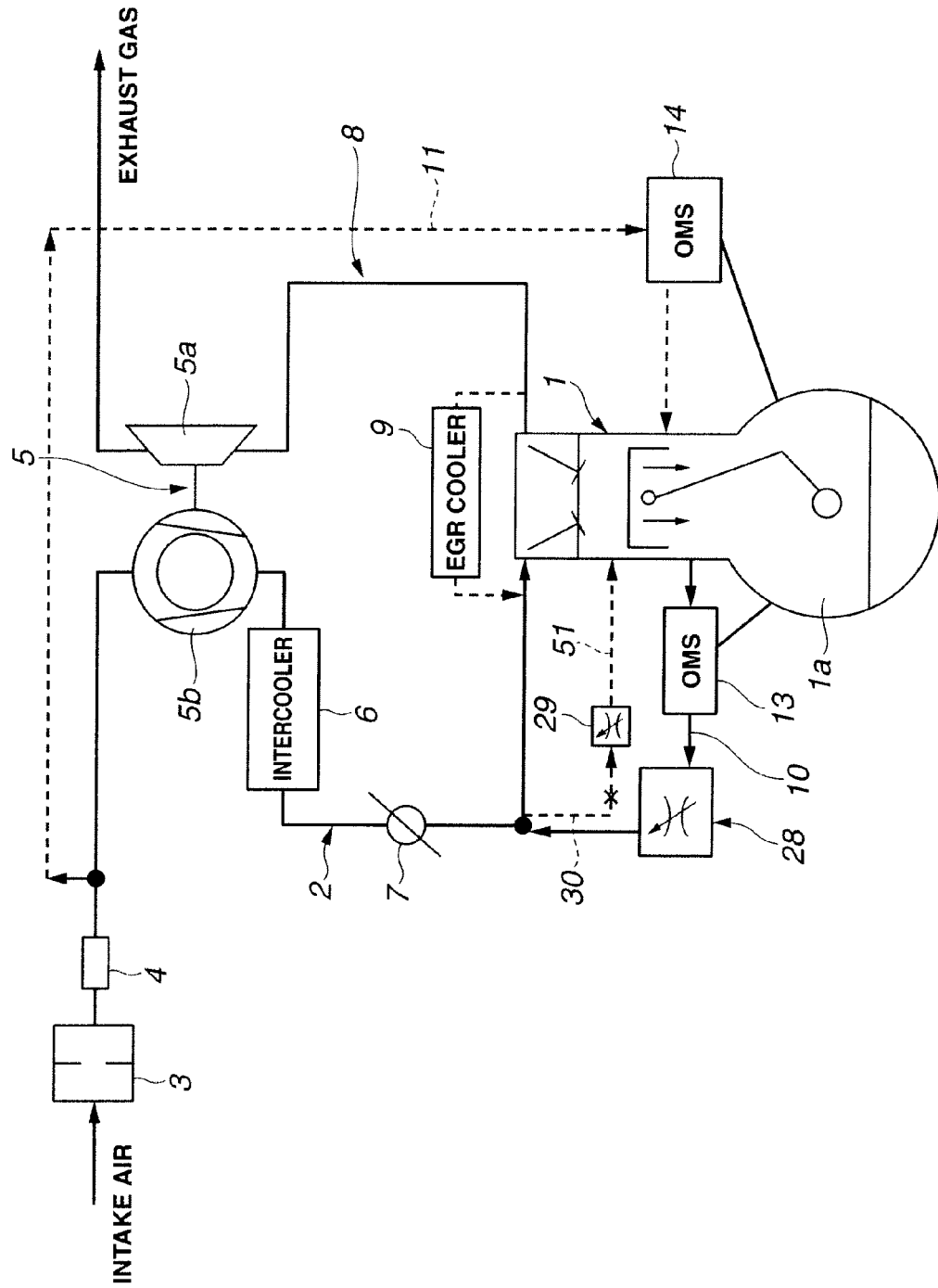


FIG.13

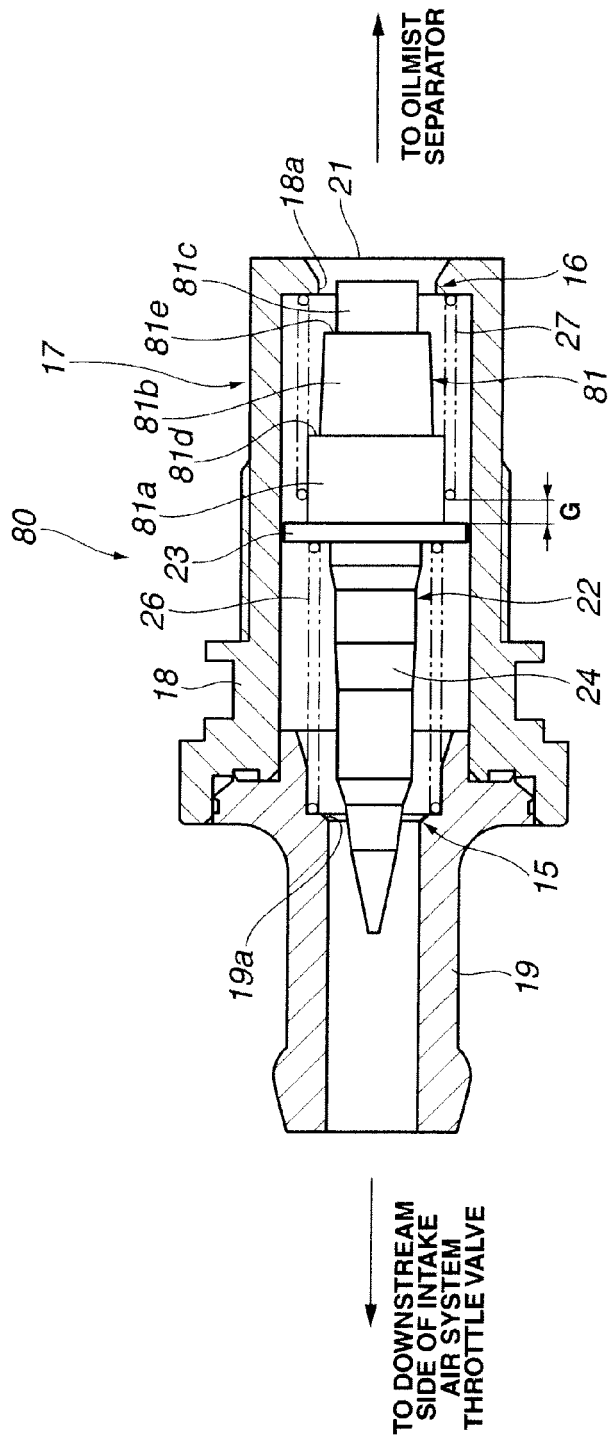


FIG.14

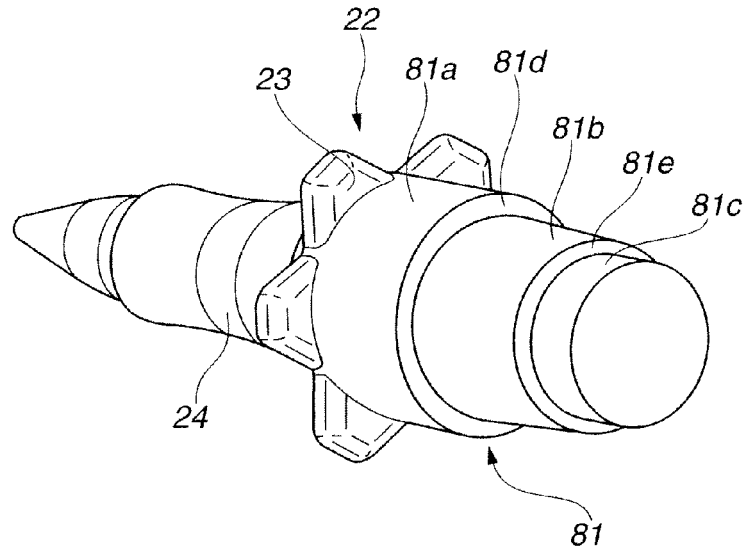


FIG.15

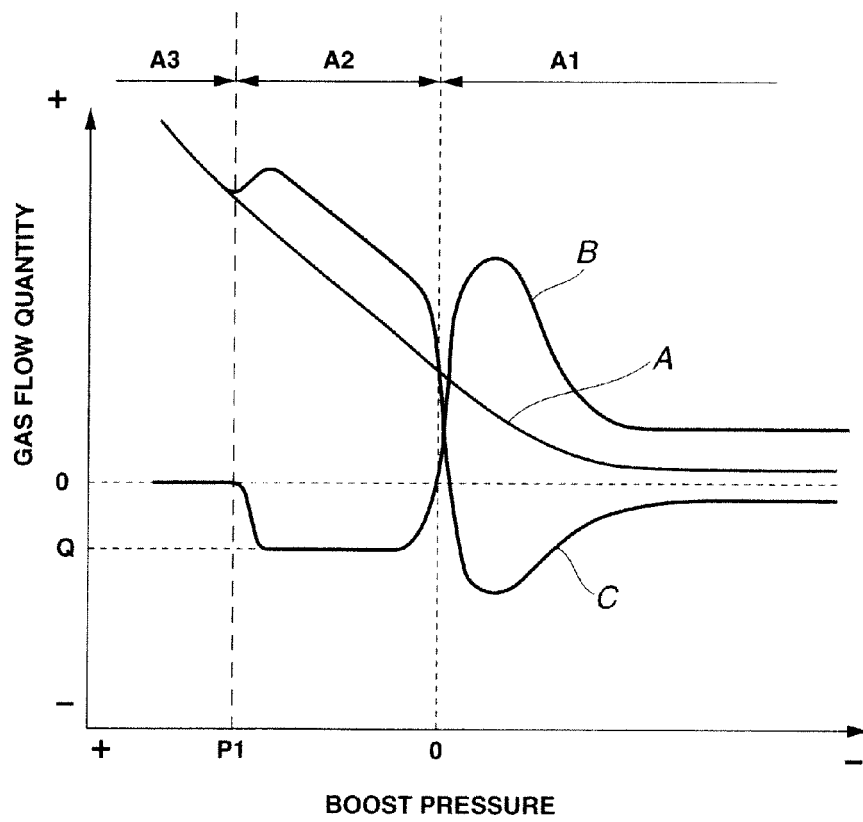


FIG.16A

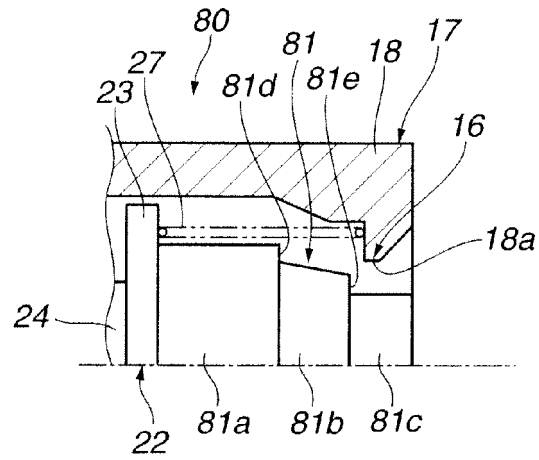


FIG.16B

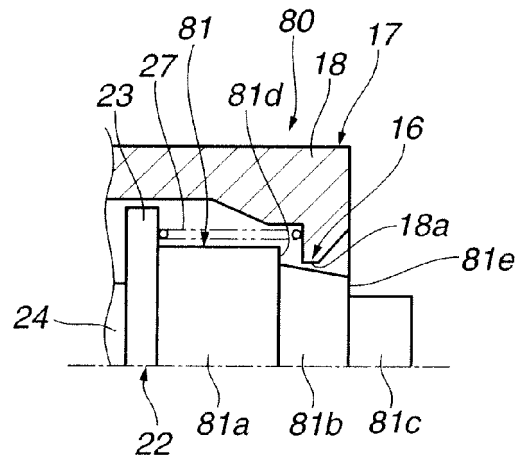


FIG.16C

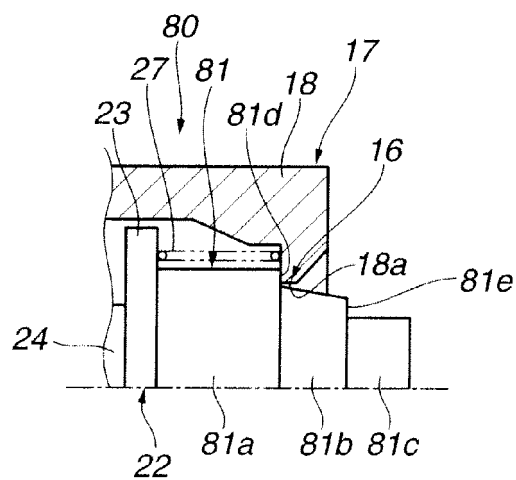


FIG.17

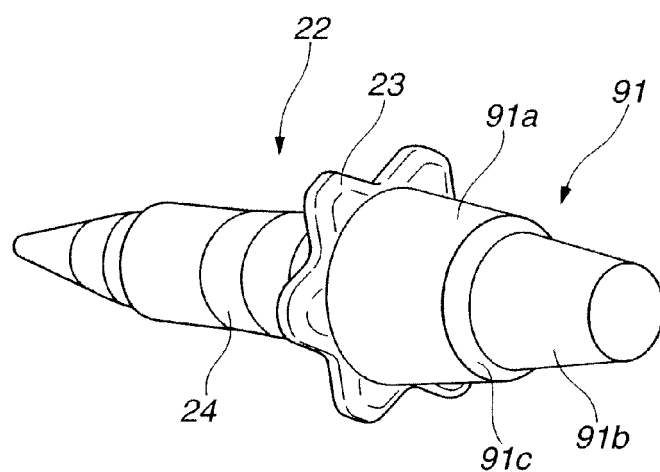


FIG.18

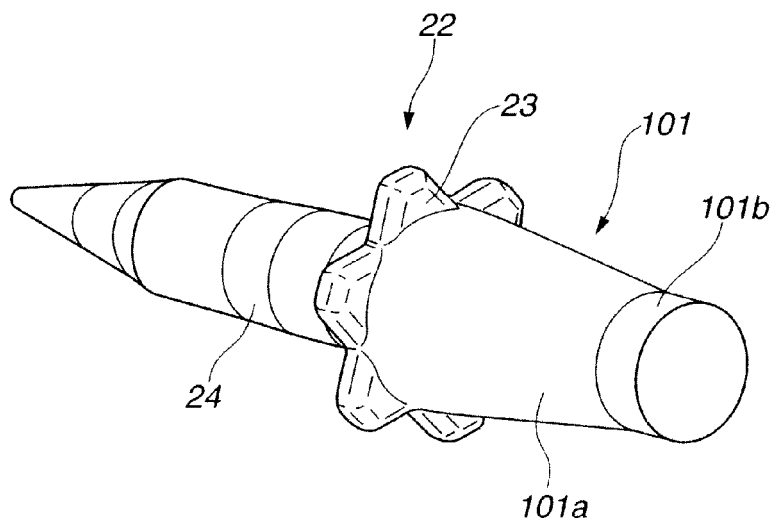


FIG.19

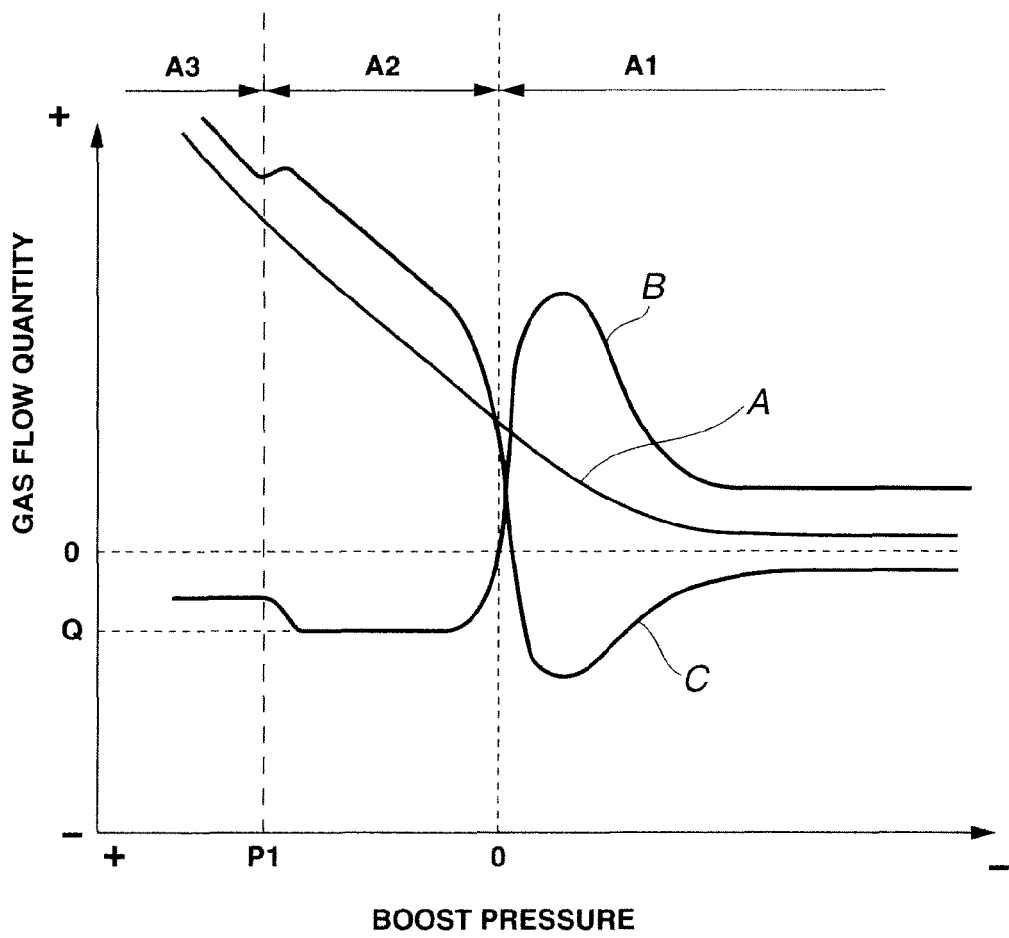


FIG.20

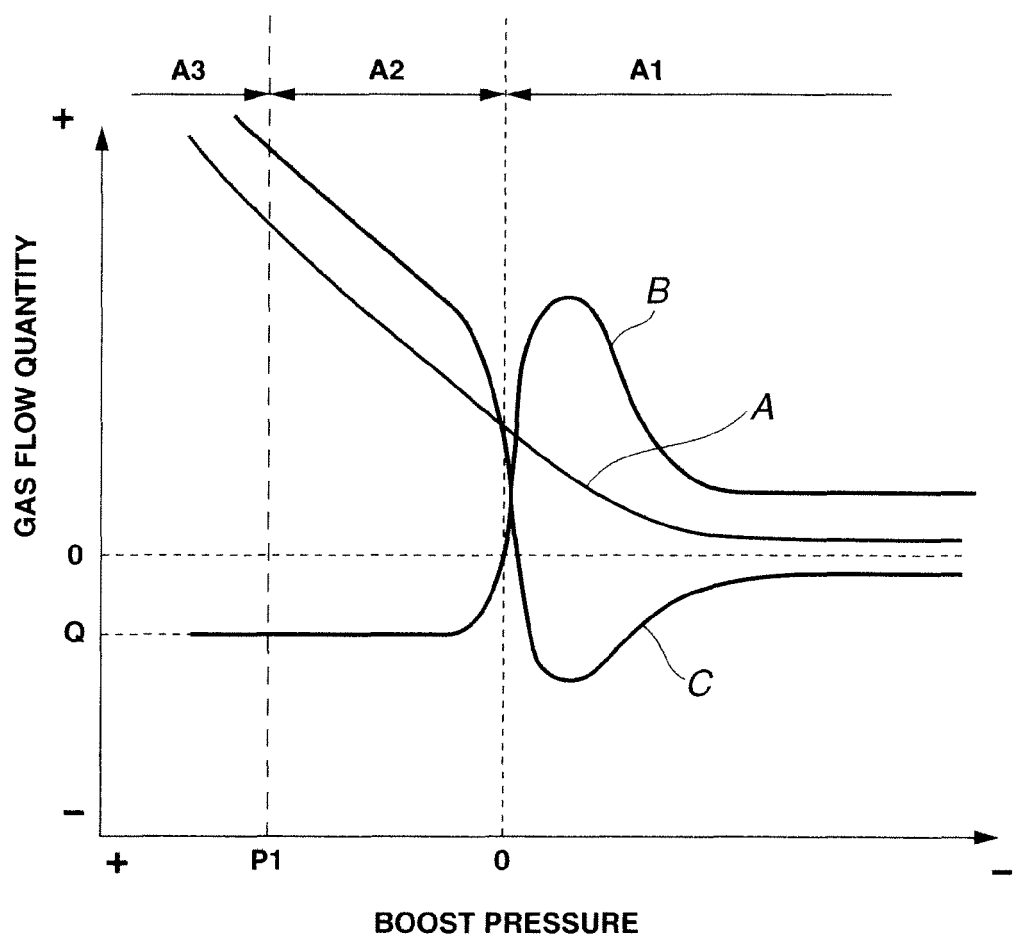


FIG.21

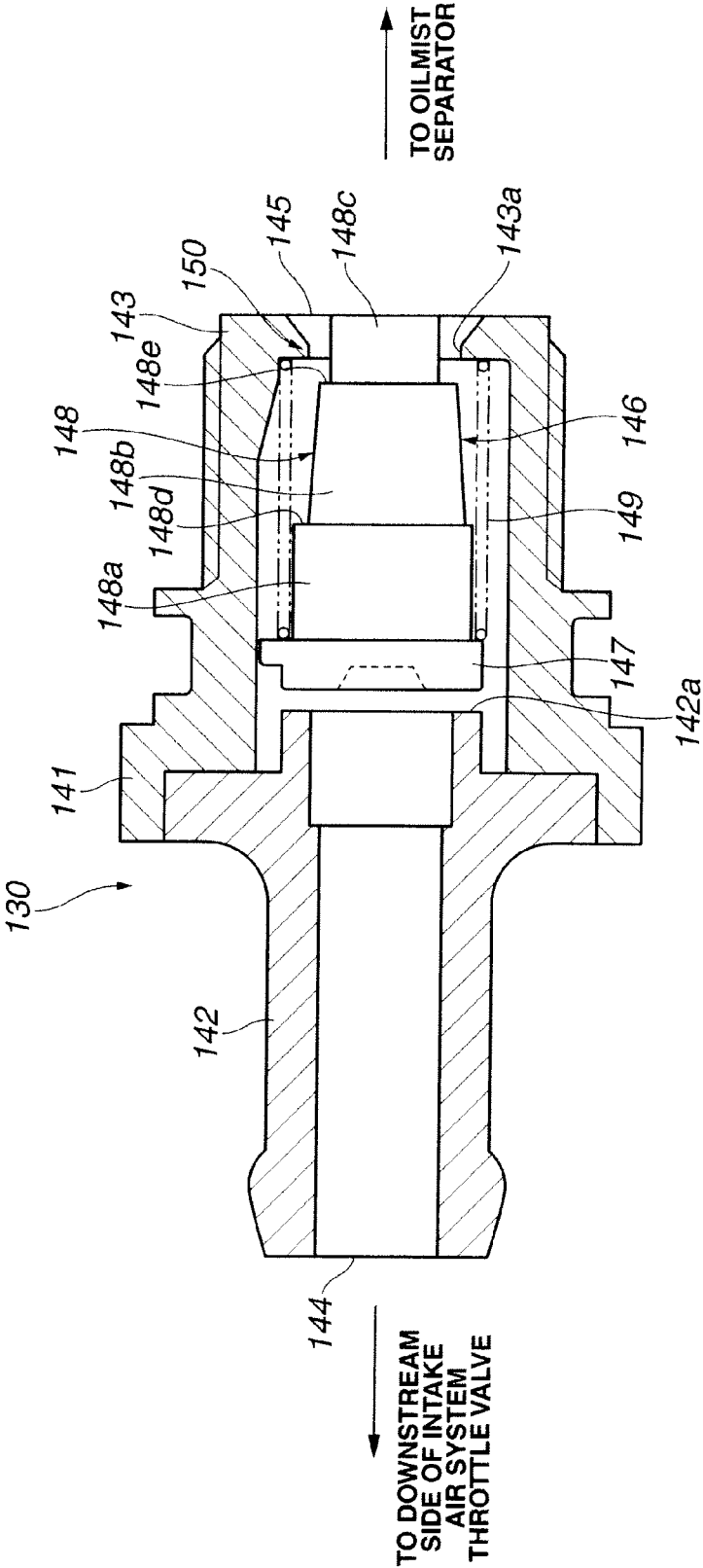
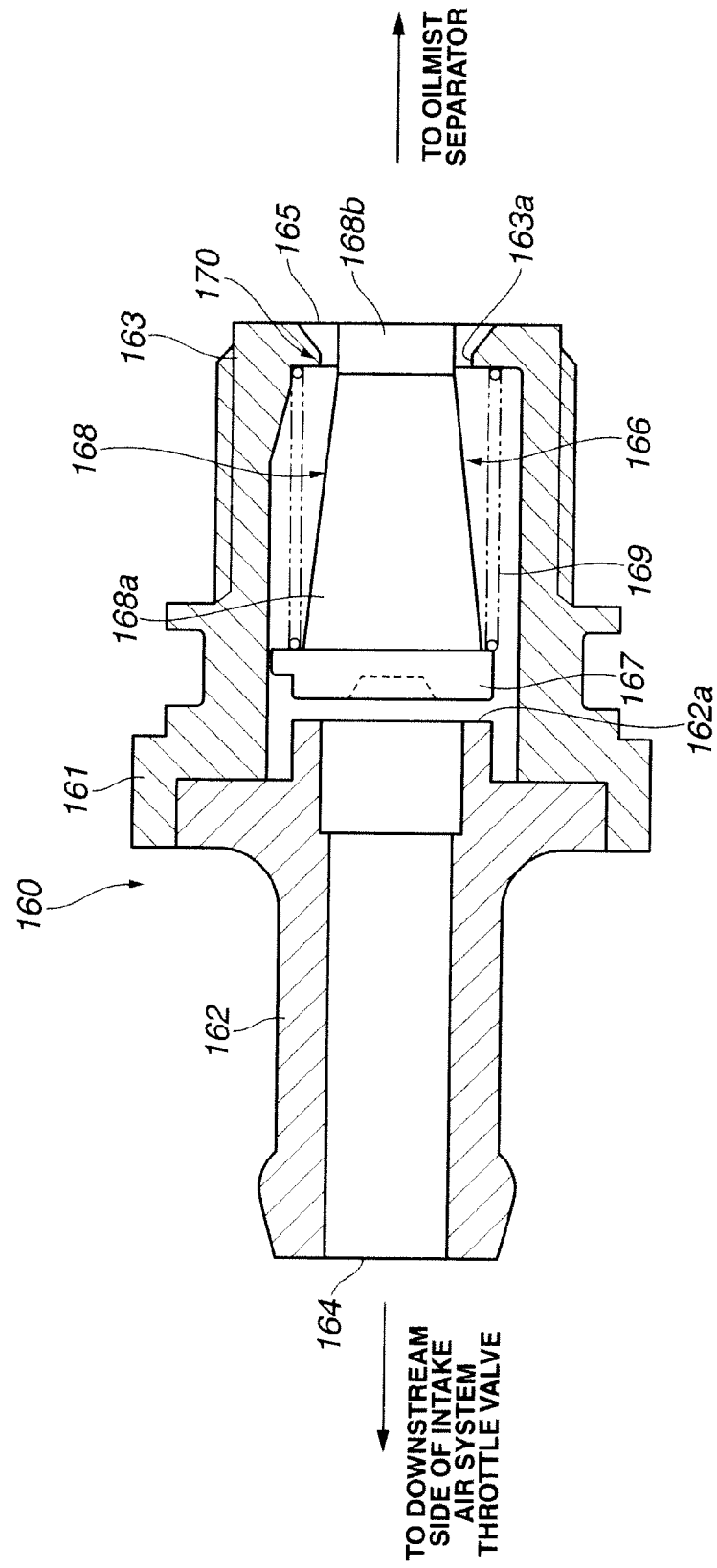


FIG.22



REFERENCES CITED IN THE DESCRIPTION

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