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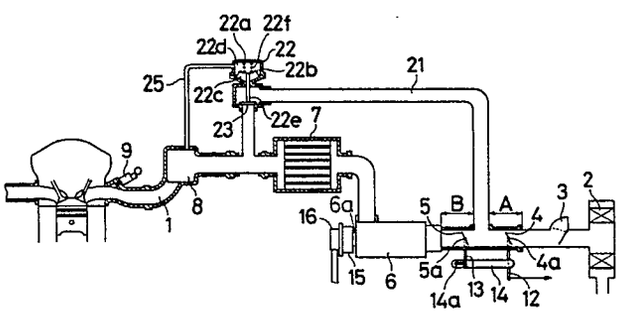
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(54) Supercharging device of an engine.

(57) In the present invention, in addition to a main throttle valve which is conventional, a sub-throttle valve for exclusive use of a supercharger is provided. By this sub-throttle valve, a flow rate of intake air is throttled by the fixed amount when the mechanical supercharger is switched from a non-connected state over to a connected state. This makes it possible to prevent supercharged air from being bypassed to the upper stream of the supercharger through the bypass and also prevent generation of air intake noises. Moreover, in the case where the mechanical supercharger is of a type involving the interior compression, at the time of switching operation of the switching means, torque shock can be prevented and controllability on engine output by the accelerator pedal is improved.

FIG. 1



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Supercharging device of an engine

BACKGROUND OF THE INVENTION

(Field of the Invention)

This invention relates to a supercharging device of an engine which is provided with a mechanical supercharger.

(Description of a prior art)

As a supercharging device of an engine, such a device as disclosed by the Japanese Utility Model Registration Application Laying Open Gazette No.61-78250, for example, has been known. According to this device, a mechanical supercharger which is driven by an engine is provided in an air intake passage downstream from a throttle valve and a supercharging control valve is provided in the air intake passage between the mechanical supercharger and the throttle valve, whereby when a supercharging pressure reaches a set point, the supercharging pressure is maintained at that set point by adjusting the opening of the supercharging control valve so as to rationalize supercharging characteristics.

Another supercharging device as disclosed by the Japanese Utility Model Registration Application Laying Open Gazette No.61-17138 is such that a mechanical supercharger which is driven by an engine is provided in an air intake passage, a bypass which bypasses the mechanical supercharger is provided at the air intake passage, a throttle valve is provided in the air intake passage upstream a joint of the bypass on an intake side of the supercharger and a diaphragm type control valve which opens in response to an air intake negative pressure is provided in the bypass. According to this supercharging device, when required output is small and negative pressure at the downstream of the throttle valve is large, the control valve opens, whereby supercharged air at the downstream from the supercharger is supplied to the upper stream of the supercharger via the bypass so as to relieve negative pressure of intake air and prevent a temperature rise in the air intake passage. On the other hand, when required output is large and a supercharging pressure at the downstream of the supercharger is also large, the control valve which has a function of a check valve opens by application of the supercharging pressure so as to relieve the supercharged air at the downstream from the supercharger to the upper stream of the supercharger via a bypass and prevent overmuch of the supercharging pressure.

In the above supercharging device provided with a mechanical supercharger, a bypass and a control valve in an air intake passage, it is suggested to provide a clutch between the mechanical supercharger and an output shaft of engine so as to put the mechanical supercharger in a non-connected state, when required output is small, by turning the clutch "OFF" and thereby supply intake air to the engine through the bypass and when required output is large, to put the mechanical supercharger in a connected state by turning the clutch "ON" and thereby supercharge the engine. With the above arrangement, when required output is small, power to be absorbed by the mechanical supercharger becomes zero, with the result of reduction in fuel expenses and when required output is large, it is possible to secure engine output.

However, in the above supercharging device with a clutch, when the clutch in "OFF" state turns "ON" with the increase of required output and the mechanical supercharger is switched from "non-connected state" over to "connected state", the mechanical supercharger is driven suddenly and the flow rate of discharge air of supercharger increases. In this case, due to an overcharged pressure at the downstream from the supercharger, a control valve opens and supercharged air is relieved to the upper stream of the supercharger through the medium of a bypass. Therefore, a sound generated by the variation of pressure in the supercharger and other factors are transmitted to the upper stream side of the supercharger as it is carried by the flow of the relieved air, with the result that a noise goes up the air intake passage and is emitted outside.

SUMMARY OF THE INVENTION

A primary object of the present invention is to prevent generation of air intake noises by preventing supercharged air from being relieved to the upper stream of a supercharger via a bypass when the mechanical supercharger is switched from "non-connected state" over to "connected state".

In order to attain the above object, in the present invention a sub-throttle valve for exclusive use of the supercharger is provided in addition to a main throttle valve and by means of this sub-throttle valve, a flow rate of intake air is further throttled by the fixed quantity when the mechanical supercharger is switched from the "non-connected

state" over to "connected state".

In concrete, in order to solve problems raised by conventional supercharging devices, the supercharging device according to the present invention is provided with an air intake passage for supplying intake air to an engine a mechanical supercharger to be driven by an output shaft of an engine provided in the air intake passage, a switching means to switch the mechanical supercharger from "connected state" over to "non-connected state" in relation to the output shaft of the engine, a bypass made in the air intake passage for bypassing the mechanical supercharger, a main throttle valve provided in the air intake passage upstream a joint of the bypass on an intake side of the supercharger, and a sub-throttle valve provided in the air intake passage between a joint of the bypass on an intake side of the supercharger and the mechanical supercharger. With this arrangement, when the mechanical supercharger is switched from "non-connected state" over to "connected state" by the above switching means, the sub-throttle valve throttles the flow rate of intake air by the fixed quantity, in addition to throttling of the flow rate of intake air by the main throttle valve and after the above switchover, the sub-throttle valve opens according to the increase of required output of the engine or opens with a time lag.

According to the present invention with the above construction, when required output is small, for example, the mechanical supercharger is put in "non-connected state" by the operation of a switching means, whereby intake air is supplied to an engine through a bypass and power to be absorbed by the mechanical supercharger becomes zero, with resultant reduction in fuel expenses.

On the other hand, when required output is large, the mechanical supercharger is put in "connected state" by the operation of a switching means, whereby an engine is supercharged and output of engine is secured.

With the increase of required output, when the mechanical supercharger is switched from "non-connected state" over to "connected state" the operation of a switching means, the mechanical supercharger is driven suddenly. In this case, however, the flow rate of intake air is further throttled by the fixed quantity by a sub-throttle valve, in addition to throttling of the flow rate of intake air by a main throttle valve and after the above switchover, the sub-throttle valve opens in accordance with the increase in required output of the engine or opens with a time lag and accordingly the flow rate of discharge air of the supercharger increases gradually. This means that supercharged air is supplied to a combustion chamber, without being relieved to a bypass and a noise generated in the supercharger is transmitted to the combustion chamber as it is carried by the flow of the supercharged air. Thus, emission of an intake air noise from an air intake passage to the outside can be prevented.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings show preferred embodiments of the present invention, in which:

Fig.1-Fig.15 show respectively the first embodiment of the present invention, in which:

Fig.1 is a whole composition of a supercharging device of an engine;

Fig.2 is an explanatory drawing of a working area of an electromagnetic clutch:

Fig.3 shows the relation between r.p.m. of an engine and the opening of an accelerator;

Fig.4 shows the relation between r.p.m. of an engine and r.p.m. of a supercharger;

Fig.5 shows the relation between the opening of an accelerator and the opening of a main throttle valve;

Fig.6 shows the relation between the opening of an accelerator and the opening of a sub-throttle valve,

Fig.7 shows the relation between the opening of an accelerator and operation of an electromagnetic clutch;

Fig.8 shows the relation between the opening of an accelerator and opening of a adjusting valve;

Fig.9 shows the relation between the opening of an accelerator and an intake air pressure;

Fig.10 shows the time variation of the opening of a throttle valve;

Fig.11 is a front view, showing a concrete construction of an engine;

Fig.12 is a plan view of Fig.11;

Fig.13 is a side view of an upper part of an engine;

Fig.14 is a side view of a mechanical supercharger;

Fig.15 is a front view of Fig.14:

Fig.16-Fig.18 illustrate the second embodiment of the present invention in which

Fig.16 is a whole composition of a supercharging device of an engine;

Fig.17 shows the relation between r.p.m. of an engine and volumetric efficiency;

Fig.18 shows the relation between the opening of an accelerator and the opening of a sub-throttle valve; and

Fig.19 is an explanatory drawing of the working area of an electromagnetic clutch in a modified example.

DESCRIPTION OF PREFERRED EMBODIMENTS

The above object and novel features of the present invention will be made more apparent by reading the following description made with reference to the accompanying drawings.

A description is made below of each preferred embodiment of the present invention with reference to the accompanying drawings.

Fig.1 shows an outline of the composition of an engine provided with a supercharging device regarding the first embodiment of the present invention

In Fig.1, reference numeral 1 designates an air intake passage for supplying intake air to an engine. One end of the air intake passage is open to the atmosphere via an air cleaner and the other end of it is connected to a combustion chamber of the engine.

Provided in the air intake passage is a supercharer 6 to be driven by the engine. The supercharger 6 is of the so-called screw type and involves interior compression. It pressurizes air sucked from an intake at the fixed interior compression ratio and discharges it from an outlet. Reference numeral 21 designates a bypass provided in the air intake passage in such a fashion that it bypasses the supercharger 6. The bypass has a passage area which is large enough to secure a flow rate of intake air sufficient for producing required output of the engine when the switching means is in a non-connected state. A main throttle valve 4 is provided in the air intake passage upstream a joint of the bypass 21 on an intake side of the supercharger 6. A flow rate of intake air is adjusted in accordance with the opening of the main throttle valve 4. A sub-throttle valve 5 is provided in the air intake passage 1 between a joint of the bypass 21 on an intake side of the supercharger 6 and the mechanical supercharger 6 and a flow rate of intake air to be supplied to the mechanical supercharger 6 is throttled in accordance with the opening of the sub-throttle valve 5. In this case, a passage area of the air intake passage 1 upstream a joint of the bypass on an intake side of the supercharger (area shown by A in Fig.1) and that of the air intake passage 1 between a joint of the bypass on an intake side of he supercharger and the mechanical supercharger 6 (area shown by B in Fig.1) are set almost the same. The opening of the sub-throttle valve 5 is set smaller than that of the main throttle valve 4 and it is so designed that a flow rate of intake air is throttled further by the fixed quantity by the sub-throttle valve 5, in addition to throttling of a flow rate of intake air by the main throttle valve 4. Reference numeral 3 designates an airflow meter which is provided in the air intake passage 1 upstream the main throttle valve 4 and detects a flow rate of intake air. Reference numeral 7 designates an intercooler which is provided in the air intake passage downstream the intercooler 7. Reference numeral 9 designates a fuel spraying valve which is provided in the air intake passage 1 and supplies fuel to intake air by spraying.

A long first rod member 12 and a short second rod member 13 are connected to an axis of rotation 4a of the main throttle valve 4 and to an axis of rotation 5a of the sub-throttle valve 5 respectively. While a middle portion of the first rod member 12 is connected to one end of a link member 14, the other end of the second rod member 13 is connected to a hole 14a made in the other end of the link member 14. An accelerator pedal (not shown in the drawing) is connected to a top end of the first rod member 12 and it is so designed that the openings of the main throttle valve 4 and the sub throttle valve 5 are varied by working a pedal. More particularly, with the increase of the opening of accelerator, namely, with the increase of required output of engine, both throttle valves open and increase a flow rate of discharge air of the mechanical supercharger. It is so designed that in the case where a noise caused by pressure pulsation which is generated due to the difference in pressure between the discharge pressure of the mechanical supercharger 6 and the pressure in the air intake passage downstream the supercharger is emitted, the opening of the sub-throttle valve 5 is controlled to prevent such a noise.

An axis of rotation 6a of the above supercharger 6 is connected to a conventional variable pulley mechanism 16 via the electromagnetic clutch 15 as a switching means. The variable pulley mechanism 16 has a function of making its pitch diameter variable and is driven by an engine.

The electromagnetic clutch 15 switches the mechanical supercharger from "connected state" over to "non-connected state" or vice versa. More particularly, by turning the electromagnetic clutch 15 "ON", the mechanical supercharger 6 is put in "non-connected state" where engine driving power is transmittable to the mechanical supercharger 6, whereby the engine is supercharged and the engine output is secured.

On the other hand, by turning the electromagnetic clutch 15 "OFF", the mechanical supercharger 6 is put in "non-connected state" where the engine driving power is not transmitted to the supercharger 6, whereby the intake air is supplied to the engine through the bypass 21 and power to be absorbed by the supercharger 6 becomes zero,

with resultant reduction in fuel expenses. As shown in Fig.2, in consideration of the durability of clutch, the electromagnetic clutch 15 is kept "ON", excepting a low-load low-rotation area. Fig.3 shows the relation between r.p.m. of the engine and the opening of accelerator when the mechanical supercharger 6 is switched to "connected state" and to "non-connected state" .

Due to the function owned by the variable pulley mechanism 16, the mechanical supercharger 6 is so designed that the number of revolutions of it increases with the increase in r.p.m. of the engine by the characteristics shown in Fig.3.

A adjusting valve 23 which is controlled for operation by a diaphragm device 22 is provided in the course of the bypass 21. The diaphragm device 22 is provided with a casing 22a, diaphragm 23b arranged in the casing 22a, a first chamber 22c and a second chamber 22d which are divided from each other by the diaphragm 22b, a spring 22f compressed in the second chamber 22d and a rod 22e whose one end is connected to the diaphragm 22b. The other end of the rod 22e is connected to the surge tank 8 through the medium of a negative pressure passage 25. With the above arrangement, if negative pressure in the surge tank 8 is higher than a set point, the diaphragm 22b deviates against the spring force of the spring 22f and causes the adjusting valve 23 to open.

Operation of the main throttle valve 4, the sub-throttle valve 5 and the electromagnetic clutch 15 are explained below.

Fig.5-Fig.10 shown variations of the amount of each state with the increase of the opening of accelerator in the case where the mechanical supercharger 6 is switched from "non-connected state" over to "connected state" when the engine speed is about 1,000r.p.m. As shown in Fig.5, the opening of the main throttle valve 4 increases substantially in proportion to the increase of the opening of accelerator. As shown in Fig.6, when the opening of accelerator exceeds 20 degrees, the sub-throttle valve 5 which has been totally closed begins to open and thereafter increases its opening substantially in proportion to the increase of the opening of accelerator. As shown in Fig.7, when the opening of accelerator exceeds 20 degrees, the electromagnetic clutch 15 which has been in "OFF" state is switched to "ON" and the supercharger 6 is switched from "non-connected state" over to "connected state", a flow rate of intake air is further throttled by the fixed quantity by the sub-throttle valve 5, in addition to throttling of flow rate of intake air by the main throttle valve 4. After the above switchover, the sub-throttle valve 5 opens in accordance with the increase of required output of the engine and a flow rate of discharge air from the mechanical supercharger 6 increases gradually. As shown in Fig.8, when the opening of supercharger exceeds 20 degrees, the adjusting valve 23 which has been totally opened is closed with the lapse of the fixed period of time.

Intake air pressure at each part of the air intake passage 1 is explained below on the basis of Fig.9.

Intake air presure P_1 immediately downstream the main throttle valve 4 rises from a negative valve substantially to the atmospheric pressure, with the increase of the opening of accelerator, as shown by a broken line in Fig.9 and when and after the opening of accelerator exceeds the level of 20 degrees, it is maintained at the level of atmospheric pressure. Intake air pressure P_2 immediately downstream the sub-throttle valve 5 conforms substantially to the intake air pressure P_1 until the opening of accelerator exceeds the level of 20 degrees and intake air begins to be suched in by the supercharger 6, the intake air is throttled by the sub-throttle valve 5 and its pressure drops abruptly but thereafter rises to the level of atmospheric pressure due to the increase of the opening of the sub-throttle valve 5 with the increase of the opening of accelerator, as shown by a chain line in Fig.9. On the other hand, intake air pressure P_3 in the surge tank conforms to the intake air pressure P_1 until the opening of accelerator exceeds substantially 20 degrees but when and after the opening of accelerator exceeds 20 degrees and the mechanical supercharger 6 is put in "connected state", it rises by the fixed amount and thereafter continues to rise with the increase of the opening of accelerator, as shown in by a solid line in Fig.9. The intake air pressure P_3 rises by the fixed amount when the opening of accelerator exceeds substantially 20 degrees and an increase in torque to be obtained by this rise of pressure is absorbed as a driving torque of the mechanical supercharger 6. Therefore, torque to be obtained finally is connected smoothly even near the part where the mechanical supercharger 6 is switched from "non-connected state" over to "connected state".

The relation between the intake air pressure P_2 immediately downstream the sub-throttle valve 5 and the intake air pressure P_3 in the surge tank will be examined below.

As shown in Fig.9, where P_{X2} is an air intake pressure P_2 at the arbitrary opening of accelerator x, P_{X3} is an air intake pressure P_3 at the arbitrary opening of accelerator x, V_E is a sucking in force of an engine (volume of intake air sucked in by the engine per unit hour) and V_S is a sucking in force of the mechanical supercharger 6 (volume of intake air sucked in by the supercharger 6 per unit hour), the following relationship is established. $(V_E) \times (P_{X3}) - /V_S = P_{X2}$

However, influence by inertia surcharging effect of

intake system and influence exerted by variations of r.p.m. of the mechanical supercharger 6 by a variable pulley are disregarded in the above case. Therefore, from the above formula, ratio τ between P_{X2} and P_{X3} is

$\tau = P_{X3}/P_{X2} = V_S/V_E$

Thus, τ takes a fixed value on the basis of V_S and V_E which are peculiar to the engine with a supercharger, namely, the ratio between the intake air pressure P_2 and the intake air pressure P_3 always takes a fixed value. Therefore, if the interior compression ratio of the mechanical supercharger 6, namely, the ratio of discharge pressure to the intake pressure is set to correspond to this, discharge pressure of the mechanical supercharger 6 substantially conforms to the intake pressure at the downstream from the mechanical supercharger and generation of pressure pulsation near the outlet of the mechanical supercharger 6 is restricted. In addition, supercharged air discharged from the mechanical supercharger 6 is supplied to a combustion chamber, without being relieved to the bypass 21, and a noise generation from the mechanical supercharger is transmitted to the combustion chamber as it is carried by a flow of supercharged air. Therefore, there is no fear that intake noise is emitted outside from the air intake passage 1.

Since the discharge pressure of the mechanical supercharger 6 substantially corresponds to the intake air pressure at the downstream from the supercharger and torque to be obtained finally is connected smoothely even near the part where the mechanical supercharger 6 is switched over, there is no generation of torque shock at this switchover.

In addition, since the sub-throttle valve 5 is provided besides the main throttle valve and a flow rate of intake air toward the mechanical supercharger 6 is controlled carefully by the sub-throttle valve 5 in an operating area where the mechanical supercharger 6 is driven, controllability of engine output by the accelerator pedal is improved.

An explanation is made below of the intake air pressure and flow rate of intake air, using concrete numerical values.

(1) In the case of 700-3,000 r.p.m.

At the time of low load, the electromagnetic clutch 15 is "OFF", the mechanical supercharger 6 is not driven, the opening of the main throttle valve 4 is slight, the sub-throttle valve 5 is closed, and the bypass 21 is in intercommunicative state. Therefore, intake air flows through the bypass 21 and a natural air intake state is obtained. Suppose the maximum supercharged pressure and the flow rate of air at that time are 2 atm and V respectively, the pressure at the downstream of the main throttle valve 4 is about 0.4 atm and the amount of air intake is 1/5 of the maximum air intake amount V.

If the opening of accelerator increases, the main throttle valve 4 opens to some extent but the sub-throttle valve 5 still remains "closed", the electromagnetic clutch 15 is still "OFF" and the mechanical supercharger 6 is not yet driven. Therefore, the pressure at the downstream of the main throttle valve 4 is about 0.6 atm and the amount of air intake becomes 3/10 V.

If the opening of accelerator increases further and the main throttle valve 4 opens up to 20 degrees, the flow rate of intake air becomes 1/2 V and the pressure reaches as high as 1 atm. At this time, the sub-throttle valve 5 begins to open slightly.

In the above state, the electromagnetic clutch 15 turns "ON" and the bypass 21 is closed by the adjusting valve 23. In this case, intake air begins to flow through the mechanical supercharger 6 but is throttled by the sub-throttle valve 5 and the flow rate of air intake is 1/2 V.

When the electromagnetic clutch 15 is "ON", the bypass 21 is closed by the adjusting valve 23 and the mechanical supercharger 6 is driven, the pressure at the downstream of the sub-throttle valve 5 is 0.6 atm, the pressure at the upper stream of the surge tank 8 is 1.2 atm and the amount of air intake is 3/5 V.

If the opening of accelerator increases still more and high load is reached, both the main throttle valve 4 and the sub-throttle valve 5 open to the full extent, the pressure at the upper stream of the mechanical supercharger 6 becomes 1.0 atm, the intake air pressure in the surge tank becomes 2 atm and the amount of air intake becomes V.

(2) In the case of more than 3,000 r.p.m.

At the time of high speed running (engine speed of more than 3,000 r.p.m.), it raises the problem of durability of electromagnetic clutch to switch the electromagnetic clutch 15 from "OFF"to "ON". Therefore, the electromagnetic clutch 15 remains "ON".

At the time of low load, both the main throttle valve 4 and the sub-throttle valve 5 are closed, the pressure at the downstream of the main throttle valve 4 is 0.4 atm, the pressure at the downstream of the sub-throttle valve 5 is 0.2 atm, the intake air pressure at the upper stream of the surge tank 8 is 0.4 atm and the amount of air intake is 1/5 V.

If the opening of accelerator increases and medium load is reached, the main throttle valve 4 half opens, the sub-throttle valve 5 opens to some extent, the pressure at the downstream of the main

throttle valve 4 reaches about 1 atm, the pressure at the downstream of the sub-throttle valve 5 reaches 0.6 atm, the pressure of intake air to be sucked in the combustion chamber is 1.2 atm and the amount of air intake becomes 3/5 V.

If the opening of accelerator increases further and high load is reaced, both the main throttle valve 4 and the sub-throttle valve 5 open to the full extent, pressure at the upper stream of the mechanical supercharger 6 reaches 1.0 atm, pressure of intake air in the surge tank is 2 atm and the amount of air intake becomes V.

Both at the time of medium load at the time of high load, the bypass 21 is kept closed by the adjusting valve 23.

A concrete construction of the engine is explained below.

The engine is of V type. Cylinder heads 32, 33 are provided on a cylinder block 31. A left bank L and a right bank R are formed by the cylinder block 31 and the cylinder heads 32, 33. A mechanical supercharger 76 is arranged between the left bank L and the right bank R through the medium of a fitting member (not shown in the drawing) of the cylinder block 31. A driving shaft 76a of the mechanical supercharger 76 is driven for rotation by a crank shaft 37 through the medium of a pulley 38 fitted to a forward end of the crank shaft 37, two coaxial intermediate pulleys 39, 40 arranged coaxially at the right outward side of the cylinder block 31, a pulley 41 fitted to a forward end of the driving shaft 76a and two belts 42, 43 wound round between the pulleys 38, 39 and between the pulley 40, 41 respectively.

Both of the pulleys 38, 39 have conventional variable pulley mechanism which is variable in pitch diameter. With the increase of r.p.m. of the engine, while the pitch diameter of the pulley 39 becomes small, that of the pulley 38 becomes large. As a result, with the increase of r.p.m. of the engine, r.p.m. of the mechanical supercharger 76 decreases and the flow rate of intake air is regulated properly. Thus, wasteful working of the mechanical supercharger 76 is eliminated.

Each of the cylinder heads 32, 33 is provided with a cam shaft for air intake and a cam shaft for air discharge. By these cam shafts, an air intake valve and an air discharge valve are driven to carry out air suction and air discharge at the fixed timing.

While provided at a forward end of the cam shaft for air discharging at the outer side of each of the bank L and the bank R is a timing pulley 48, provided at a forward end of the crank shaft 37 is a timing pulley 49, having a pitch diameter which is one half of that of the pulley 48 and a belt 50 is wound round among the pulley 48 and the pulley 49. Through the medium of the timing belt 50, the cam shafts for air discharge valves are driven to rotate synchronously in such a fashion that up and down strokes of the right and left air discharge valves are contrary to each other. A mechanism of transmitting the rotation of the crank shaft 37 to each cam shaft for air discharge valve is composed by the timing pulleys 48, 49 and the timing belt 50.

Two idle pulleys 54 which guide the timing belt 50 are provided below and on both sides of the mechanical supercharger 76 in such a fashion that they make contact with the outer surface of the timing belt 50. By these idle pulleys 54, the timing belt 50 is forced to slope downward so that the mechanical supercharger 76 and the timing belt 50 do not interfere with each other. Also, two other idle pulleys 55a, 55b are provided above the crank shaft 37 in such a fashion that they make contact with the outer surface of the timing belt 50 and guide the timing belt 50. Of these two idle pulleys 55a, 55b, the idle pulley 55a is so designed that it functions as a tension pulley.

Provided in each of the left bank L and the right bank R is a gear 46 which is coaxial with the timing pulley 4B. By engaging the gear 46 with a gear 47, having the same pitch diameter and the same module as the gear 46, which is fitted to the cam shaft for air intake, rotation of the cam shaft for air discharge is transmitted to the cam shaft for air intake.

Reference numeral 62, 63 designate cylinder head covers arranged on the cylinder heads 32, 33 respectively. Reference numeral 64 designates a casing for a water pump which is arranged by utilizing space surrounded by the timing belt 50. Reference numeral 65 designates an oil pan disposed at the underside of the cylinder block 31.

Reference numeral 73 designates surge tanks which are provided above each of the left bank L and the right bank R and which communicate with each other so that intake air can circulate between cylinders 34 on either side. Reference numeral 74 designates an air intake passage which extends frontward from above the mechanical supercharger 76 and then branches into both sides to be connected to each surge tank 73. Reference numeral 75 designates intercoolers which are arranged with the air intake passage 74 interposed therebetween and cool down intake air to be discharged from the mechanical supercharger 76. Reference numeral 77 designates an electromagnetic clutch.

In the above embodiment, since the mechanical supercharger 76 is arranged above and between the left and right banks L, R, space above the middle of a V type engine can be utilized effectively as space for installation of auxiliary machines.

Fig 16 shows the second embodiment of the present invention. In the first embodiment, the main throttle valve 4 and the sub-throttle valve 5 are

connected mechanically to the accelerator pedal through the medium of the first rod members 12, 13 and the link member 14, but in the second embodiment, only the main throttle vaive 4′ is connected mechanically to the accelerator pedal and the sub-throttle valve 5′ is connected with an actuator 82 by which the sub-throttle valve 5′ is driven. The actuator 82 is controlled by a control unit 83. The main throttle valve 4′ is connected with a sensor 81 for detecting the opening of the main throttle valve and an output signal of the opening sensor 81 is inputted to the control unit 83.

In the above embodiment, the adjusting valve 23 which is controlled for operation by the diaphragm device 22 in the course of the bypass 21 but in the second embodiment, a check valve 90 is provided in the course of the bypass 2. The check valve 90 is equipped with a valve body 90a which opens by pressure from the upper stream of the air intake passage and closes by pressure from the downstream of the intake air passage and a spring 90b which forces the valve body 90a to take the closing direction. The check valve 90 keeps intake air from flowing to the bypass 21 when the mechanical supercharger 6′ is in "connected state". In the second embodiment, the bypass 21 communicate with the downstream of the intercooler 7. In the other basic compositions, the second embodiment is common to the first embodiment.

An explanation is made beiow of the operation control on the actuator by the control unit 83. Basically, as shown by a solid line in Fig.18, with the increase of the opening of accelerator, namely, with the increase of required output of the engine, it is so controlled that the sub-throttle valve 5′ opens and the flow rate of discharge air from the mechanical supercharger 6 increases. By this basic control, as in the case of the first embodiment such effects as prevention of generation of air intake noises, prevention of generation of torque shock and improvement of controllability on engine output by the accelerator pedal are obtained. In addition to this basic control, in the second embodiment amendments are made in due consideration of the influence by the inertia supercharging effect of air intake system and the influence exerted by variations of r.p.m of the mechanical supercharger by variable pulleys. As shown in Fig.17, the volumetric efficiency varies with r.p.m. of the engine due to the influence by the inertia supercharging effect of air intake system and the influence exerted by variations of r.p m. of the mechanical supercharger 6 by variable pulleys. In view of this, while an amendment is made so that the sub-throttle valve 5′ opens rather a little in the area where the volumetric efficiency is small, such as the area of engine low speed and the area of engine high speed, as shown in Fig.18, an amendment is made so that the sub-throttle valve closes rather a little in the area where the volumetric efficiency is large, such as the area of engine medium speed. By these amendments, air discharge pressure of the mechanical supercharger 6′ conforms exactly to the intake air pressure at the downstream from the mechanical supercharger, with the result that better effects of preventing generation of the air intake noises and preventing generation of torque shock are obtained.

In each of the above embodiments, when the mechanical supercharger 6 is switched from "non-connected state" over to "connected state", the sub-throttle valve 5 throttles further the flow rate of intake air by the fixed amount, in addition to throttling of the flow rate of intake air by the main throttle valve and after the switchover, the sub-throttle valve 5 opens in accordance with the increase of required output of the engine but after the switchover, the sub-throttle valve 5 may open with the fixed time lag. This is especially suitable for the engine which shows a small residual amount of the openeing after the switchover of the mechanical supercharger 6 from "non-connected state" over to "connected state".

The present invention is not limited in its application to the engine in esch of the above embodiments but is applicable to the engine of so-called OHC type which utilizes cam shaft common to the air discharge and air intake. In addition, the mechanical supercharger for the present invention is not necessarily be a screw type mechanical supercharger in each of the above embodiments or a mechanical supercharger which involves interior compression.

Claims

1. A supercharging device of an engine comprising:
a air intake passage for supplying intake air to the engine,
a mechanical supercharger which is provided in said air intake passage and is driven by an output shaft of the engine,
a switching means which switches said mechanical supercharger from a connected state over to a non-connected state in relation to said output shaft of the engine,
a bypass provided in said air intake passage in such a fashion that it bypasses said mechanical supercharger,
a main throttle valve provided in the air intake passage upstream a joint of the bypass on an intake side of the supercharger, and
a sub-throttle valve provided in the air intake passage between a joint of the bypass on an intake

side of the supercharger and the mechanical supercharger,
said sub-throttle valve throttles further a flow rate of intake air by the fixed amount in addition to throttling of a flow rate of intake air by the said main throttle valve when the mechanical supercharger is switched from a non-connected state over to a connected state and after this switchover, opens in response to an increase of required output of the engine or opens with a time lag

2. A supercharging device of an engine as defined in Claim 1, wherein the switching means is so designed that it is put in a non-connected state at the time of low load and put in a connected state at the time of high load.

3. A supercharging device of an engine as defined in Claim 2, wherein a adjusting valve which opens when at least the switching means is in a non-connected state is provided in the bypass and the bypass has a passage area which is large enough to secure a flow rate of intake air sufficient for producing required output of the engine when the switching means is in a non-connected state.

4. A supercharging device of an engine as defined in Claim 3, wherein the adjusting valve is so designed that it closes from an opened state at almost the same time as the switching means is switched from a non-connected state over to a connected state.

5. A supercharging device of an engine as defined in Claim 3, wherein the adjusting valve is a one-way valve which opens only when a pressure of intake air on a discharge side of the supercharger is lower than a pressure of intake air on an intake side of the supercharger.

6. A supercharging device of an engine as defined in Claim 4, wherein the sub-throttle valve is so designed that it increases its opening, together with the main throttle valve, in response to an increase of required output of the engine after the switching means is switched from a non-connected state over to a connected state.

7. A supercharging device of an engine as defined in Claim 6, wherein the sub-throttle valve is so designed that its opening increases by such a degree that output torque of the engine equals to driving torque of the mechanical supercharger when the switching means is switched from a non-connected state over to a connected state.

8. A supercharging device of an engine as defined in Claim 7, wherein the switching means is so designed that it is in a connected state while the engine running speed is more than a fixed number of revolutions, even at the time of low load.

9. A supercharging device of an engine as defined in Claim 8, wherein the mechanical supercharger is of a type involving the interior compression.

10. A supercharging device of an engine as defined in Claim 9, wherein the sub-throttle valve is so controlled that discharge air pressure of the mechanical supercharger approaches intake air pressure at the downstream from the mechanical supercharger.

11. A supercharging device of an engine as defined in Claim 10, wherein the sub-throttle valve is so controlled that discharge air pressure of the mechanical supercharger is made almost equal to intake air pressure at the downstream from the mechanical supercharger.

12. A supercharging device of an engine as defined in Claim 9, wherein the interior compression ratio of the mechanical supercharger is set at a value to be obtained by dividing suction force of the mechanical supercharger by suction force of the engine.

13. A supercharging device of an engine as defined in Claim 9, wherein the mechanical supercharger is a screw type supercharger.

14. A supercharging device of an engine as defined in Claim 9, wherein the main throttle valve and the sub-throttle valve are connected through the medium of a link mechanism and are so designed that both interlock.

15. A supercharging device of an engine as defined in Claim 9, wherein the switching means is so designed that it receives a signal corresponding to intake air pressure at the downstream of the main throttle valve and when an absolute value of this intake air pressure becomes higher than a fixed value, it is switched from a non-connected state to a connected state, and the adjusting valve is operated by an actuator which makes intake air pressure at the downstream from the throttle value as an operating source and biassing force of a spring which is provided at the actuator and biases the adjusting valve in a closing direction is set at such force which corresponds to the foregoing fixed value.

16. A supercharging device of an engine as defined in Claim 1, wherein the mechanical supercharger is of a type involving the interior compression.

17. A supercharging device of an engine as defined in Claim 16, wherein the sub throttle valve is so controlled that discharge air pressure of the mechanical supercharger approaches intake air pressure at the downstream from the mechanical supercharger.

18. A supercharging device of an engine as defined in Claim 17, wherein the sub-throttle valve is so controlled that discharge air presure of the mechanical supercharger is made almost equal to intake air pressure at the downstream from the mechanical supercharger.

19. A supercharging device of an engine as defined in Claim 16, wherein the interior compression ratio of the mechanical supercharger is set at a value to be obtained by dividing suction force of the mechanical supercharger by suction force of the engine.

20. A supercharging device of an engine as defined in Claim 1, wherein the sub-throttle valve is so designed that when the switching means is switched from a non-connected state over to a connected state, its opening increases by such a degree that output torque of the engine corresponds to driving torque of the mechanical supercharger.

21. A supercharging device of an engine as defined in Claim 1, wherein a passage area of the air intake passage near the main throttle valve and a passage area of the air intake passage near the sub-throttle are set almost equal and the opening of the sub-throttle valve when the switching means is switched from a non-connected state over to a connected state is set smaller than the opening of the main throttle valve at that time.

22. A supercharging device of an engine as defined in Claim 1, wherein the sub-throttle valve is so controlled that after the switching means is switched from a non-connected state over to a connected state, it opens gradually with the lapse of time.

23. A supercharging device of an engine as defined in Claim 22, wherein the switching means is so designed that it is switched over in response to the opening of the actuator and at a full opening of the accelerator it is switched from a non-connected state over to a connected state.

FIG. 1

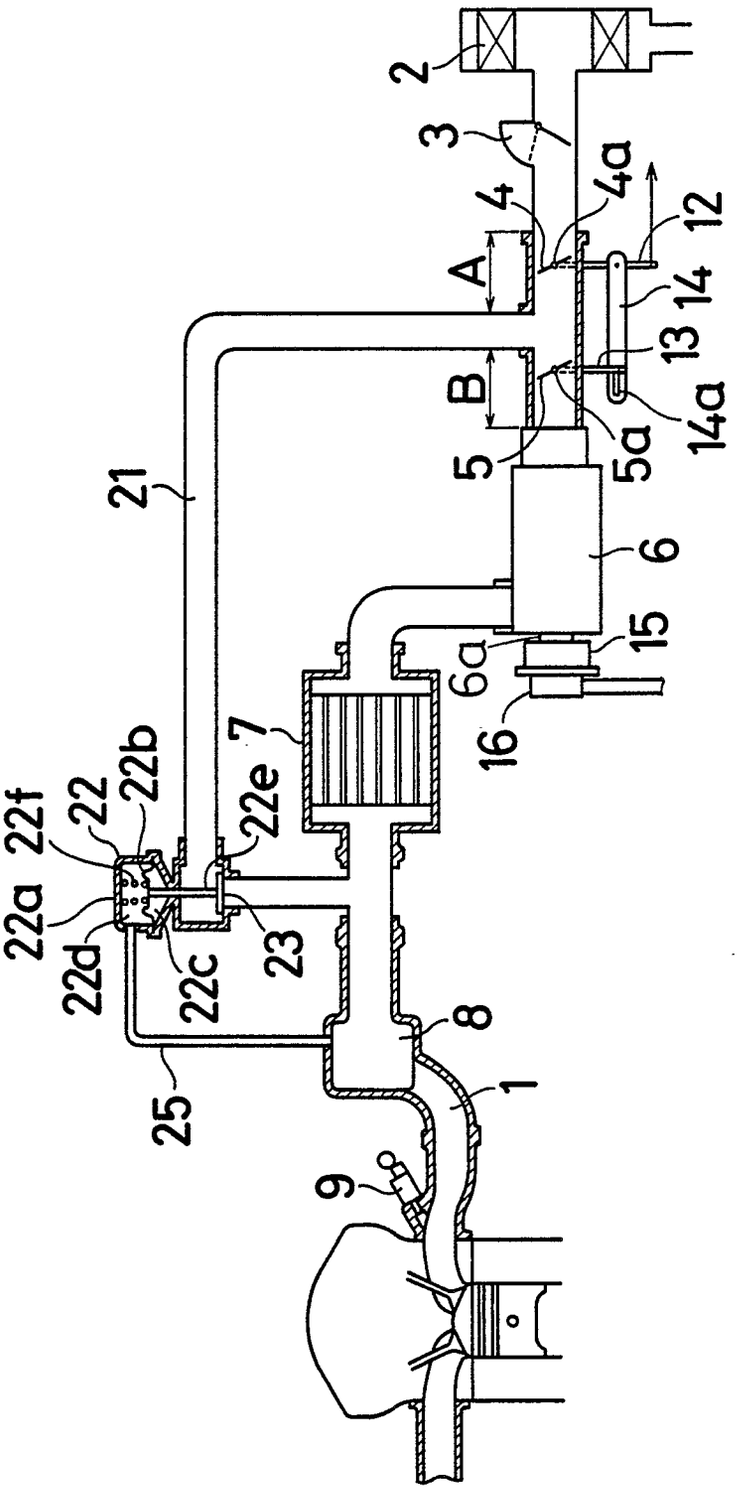

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FIG.2

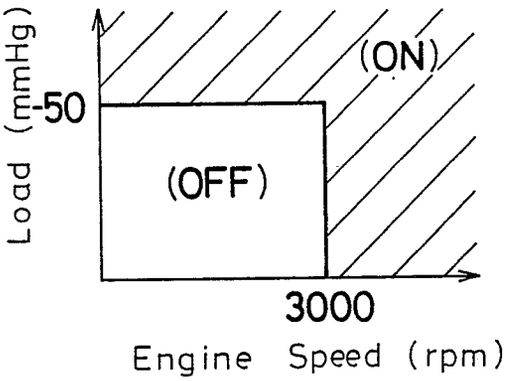


FIG.3

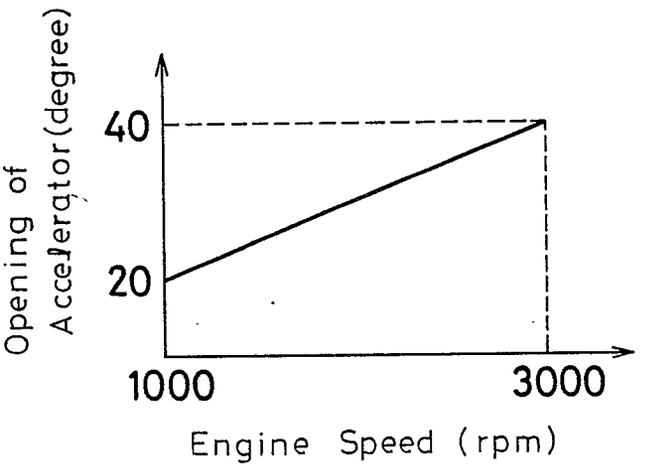


FIG.4

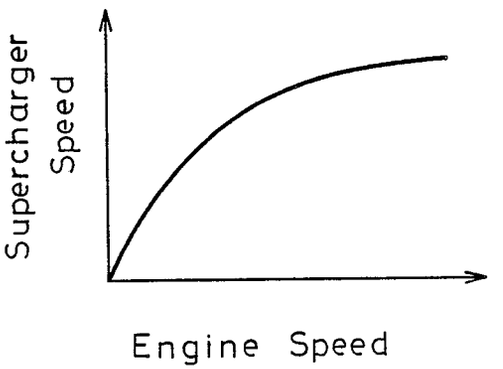


FIG. 5

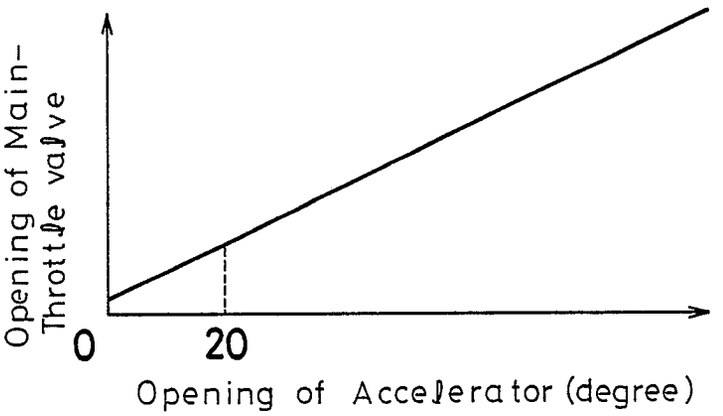


FIG. 6

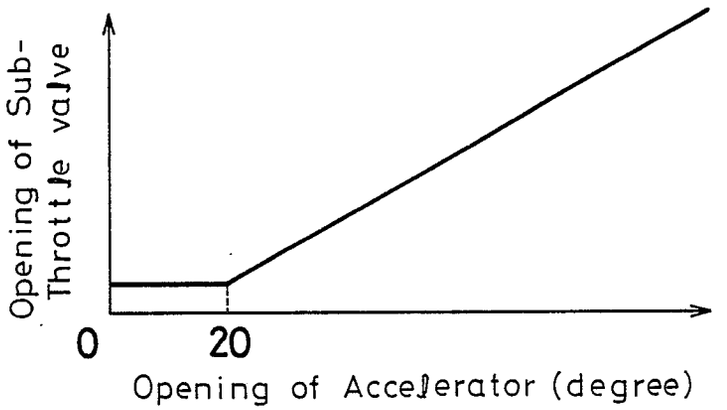


FIG. 7

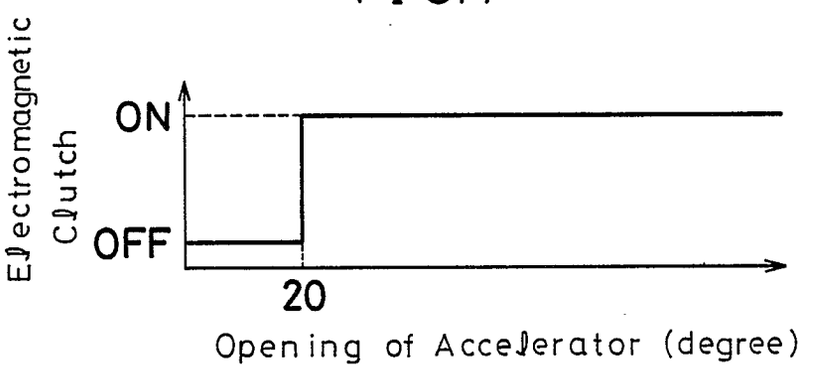


FIG. 8

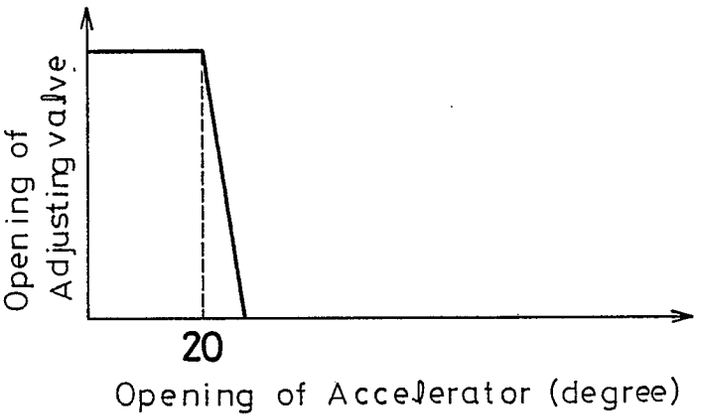


FIG. 9

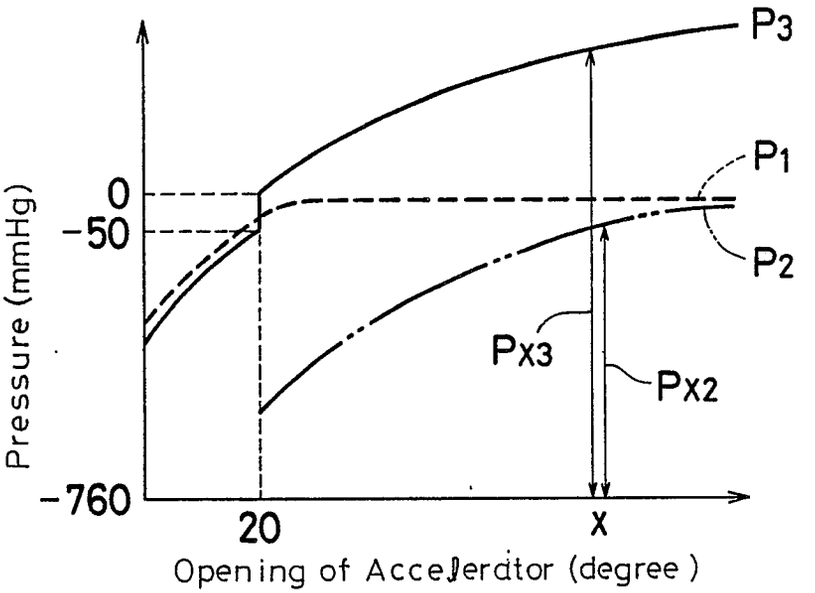


FIG. 10

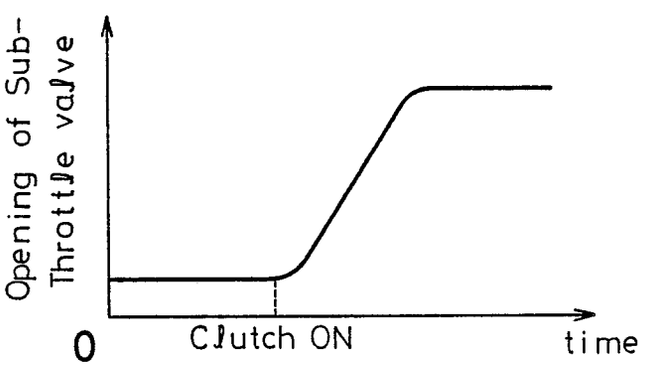


FIG.11

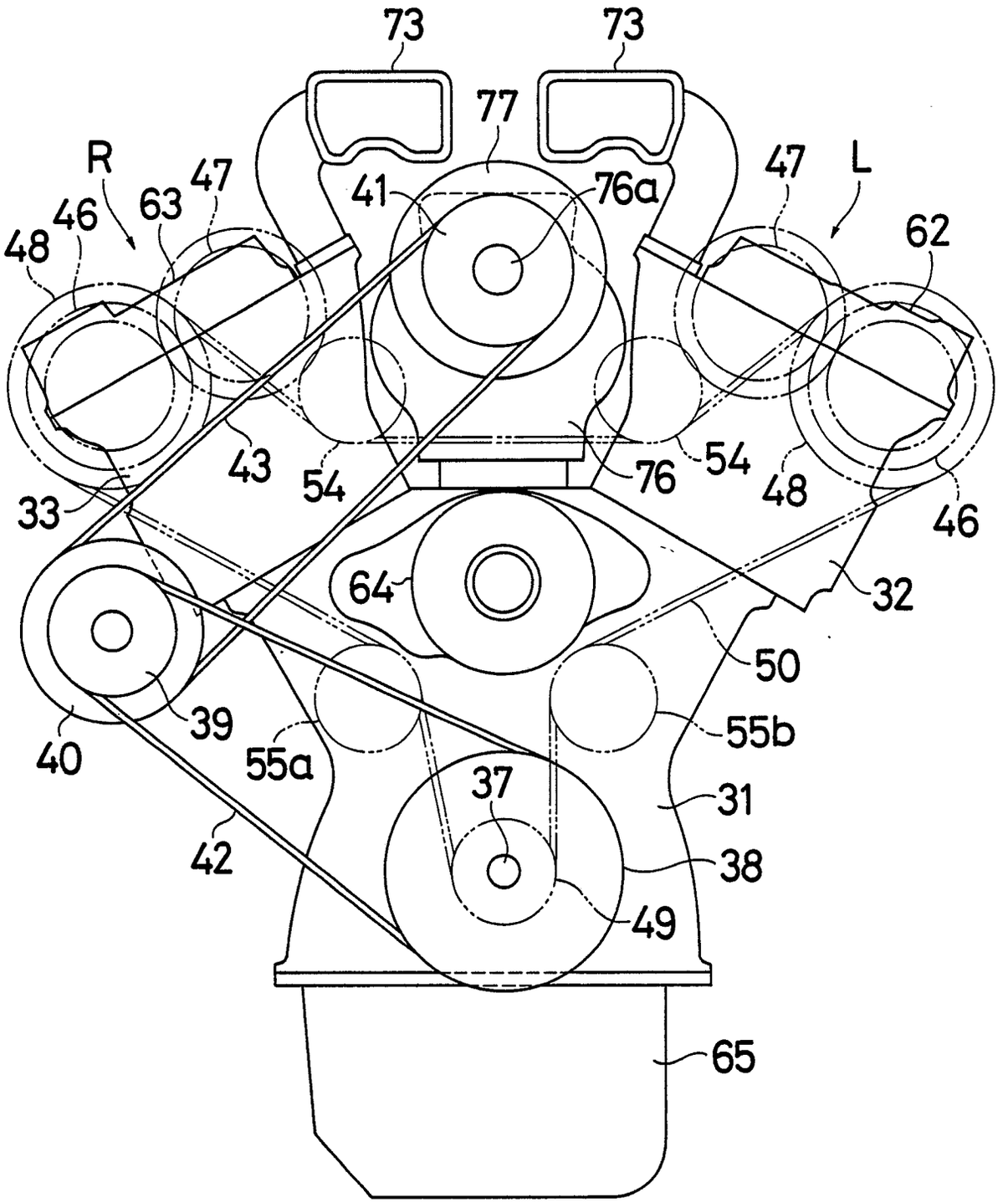

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FIG. 12

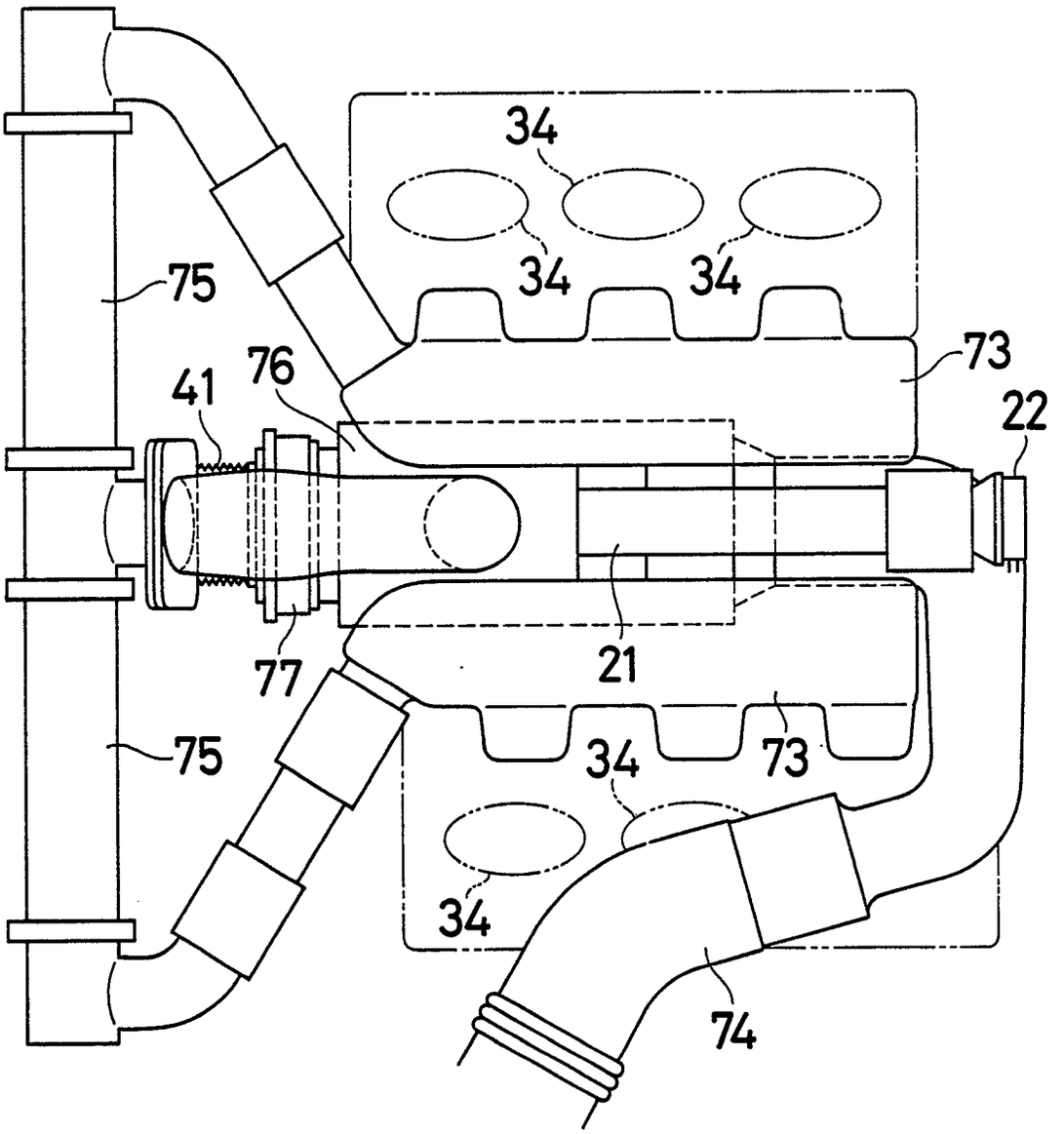


FIG. 13

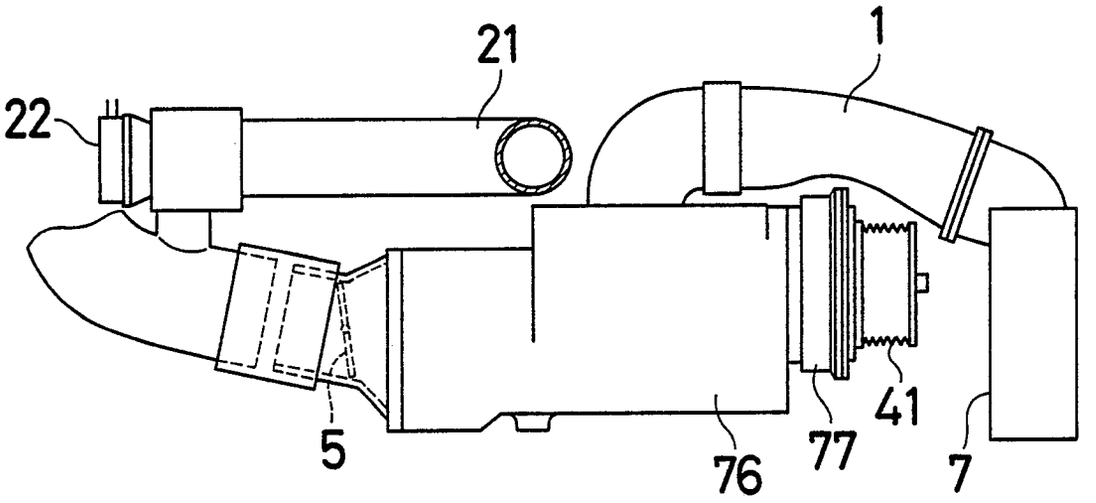


FIG.14

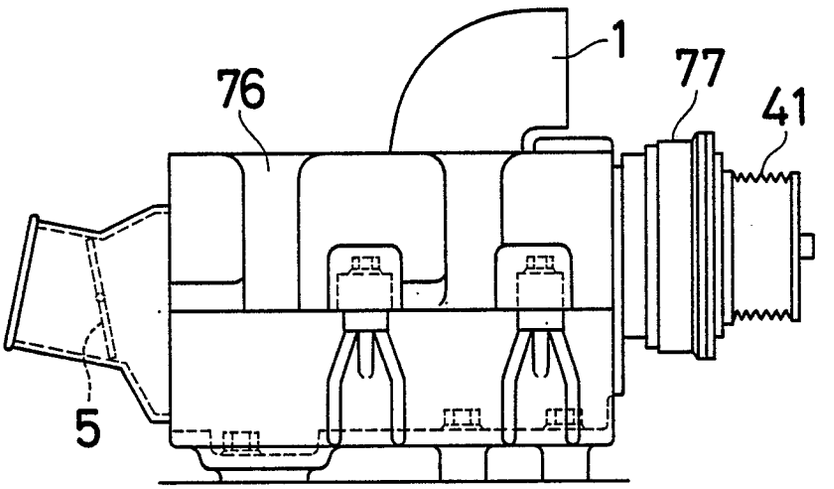


FIG.15

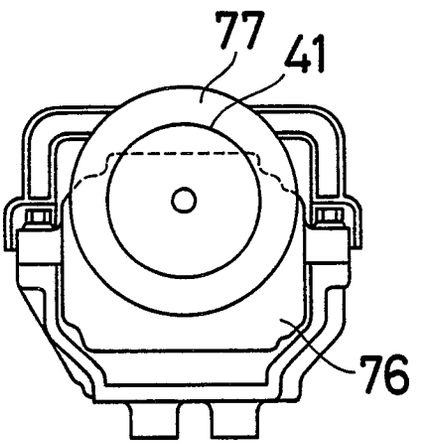


FIG.16

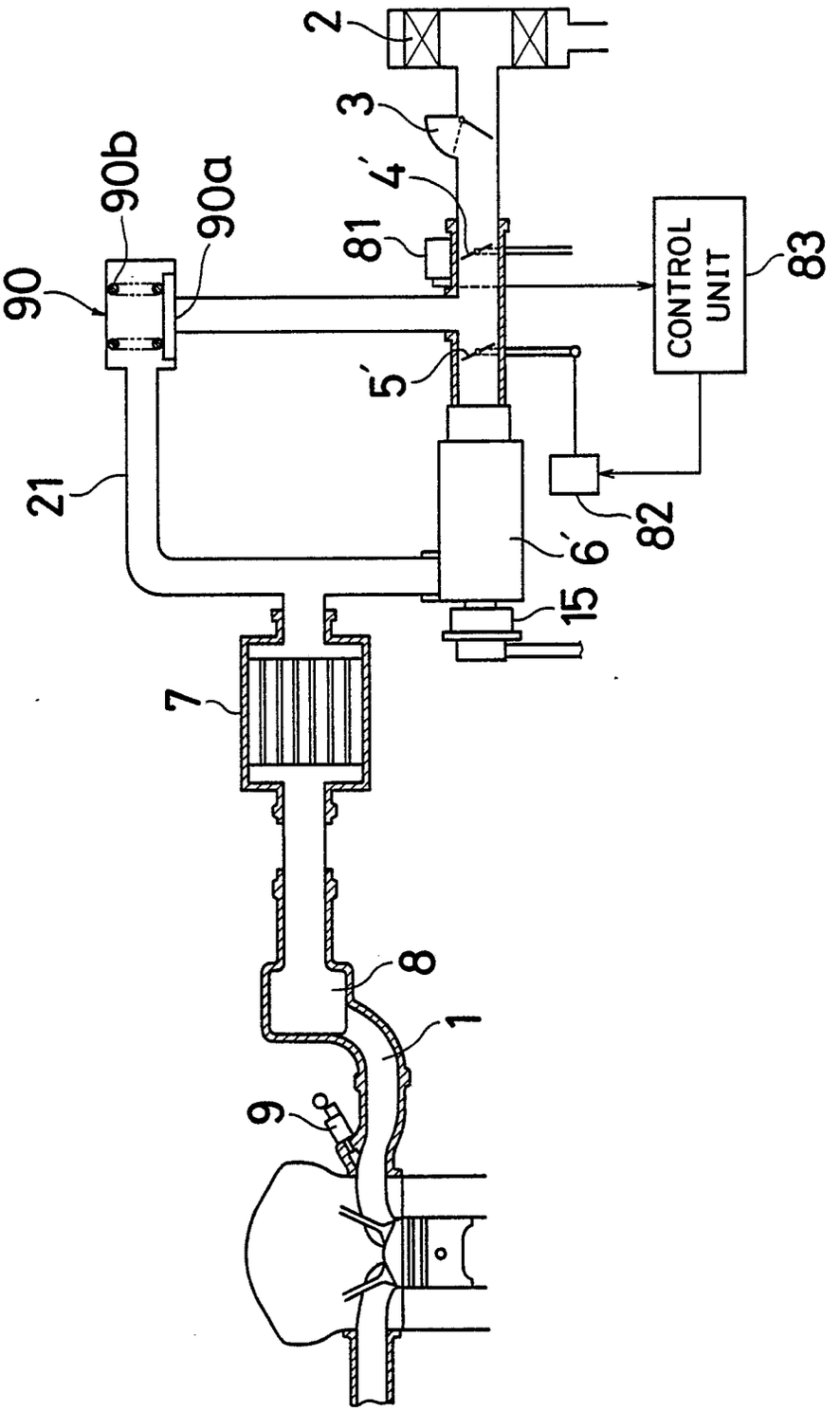


FIG.17

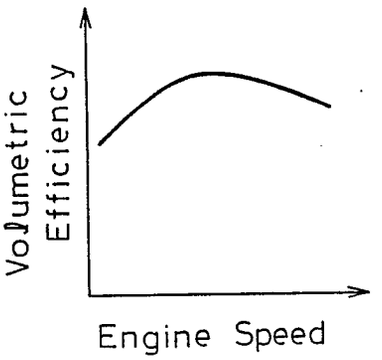


FIG.18

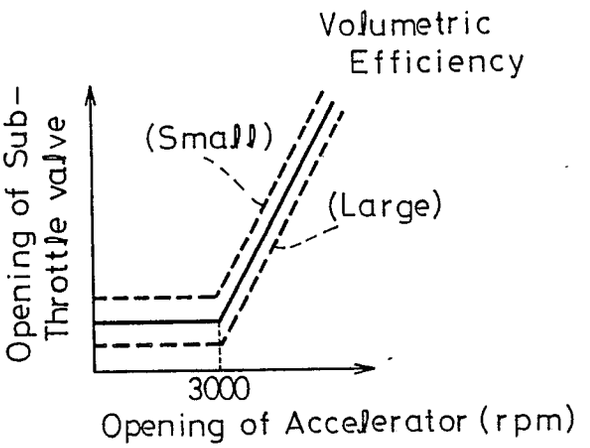


FIG.19

