(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 003 313 A2

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
17.12.2008 Bulletin 2008/51

(21) Application number: **07738722.3**

(22) Date of filing: **15.03.2007**

(51) Int Cl.:
F02D 9/04 *(2006.01)* ***F01N 3/02*** *(2006.01)*
F02D 9/10 *(2006.01)* ***F02D 11/08*** *(2006.01)*

(86) International application number:
PCT/JP2007/055272

(87) International publication number:
WO 2007/119379 (25.10.2007 Gazette 2007/43)

(84) Designated Contracting States:
DE FR

(30) Priority: **15.03.2006 JP 2006070481**
24.03.2006 JP 2006082528
27.03.2006 JP 2006084510

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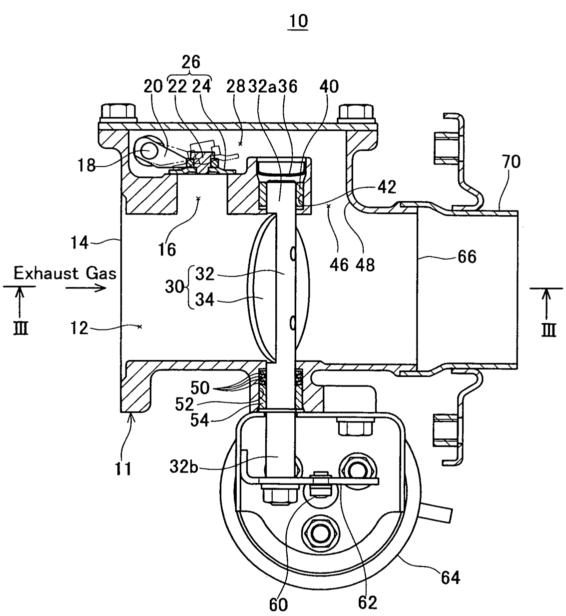
(54) EXHAUST PRESSURE CONTROL VALVE

(57) The present invention provides an exhaust pressure control valve for controlling the pressure of exhaust gas discharged from an engine. The exhaust pressure control valve is capable of reducing the amount of noise generated when a main valve of the exhaust pressure control valve is switched from a closed state to an open state.

The exhaust pressure control valve 10 of the present invention comprises a housing 11 having a main passage 12 and a bypass passage 28, a main valve 30 for opening and closing the main passage 12, and a bypass valve 28 for opening and closing the bypass passage 28. An inlet port 16 is provided in an inner wall face of the main passage 12 at an upstream side of the main valve. An outlet port 46 is provided in the inner wall face of the main passage 12 at a downstream side of the main valve. An upstream end of the bypass passage 28 is connected to the inlet port 16, and a downstream end of the bypass passage 28 is connected to the outlet port 46. A position of the outlet port 46 is offset in the circumferential direction from the position of a point on the circumferential edge of a valve member at which the distance from an axis of a rotation shaft of the main valve to the circumferential edge of the valve member is longest.

FIG. 2



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Description

Technical Field

[0001] The present application claims priority to Japanese Patent Application No. 2006-70481 filed on March 15, 2006, Japanese Patent Application No. 2006-82528 filed on March 24, 2006, and Japanese Patent Application No. 2006-84510 filed on March 27, 2006, the contents of which are hereby incorporated by reference into the present specification.

[0002] The present invention relates to an exhaust pressure control valve for controlling the pressure of an exhaust gas discharged from an engine.

Background of the Invention

[0003] An exhaust pressure control valve for controlling the pressure of an exhaust gas discharged from an engine is utilized to increase the starting ability of the engine or to clean the exhaust gas discharged from the engine. A conventional exhaust pressure control valve is disclosed in International Laid Open Patent Publication No. 99/41495.

This exhaust pressure control valve comprises a housing having a main passage and a bypass passage. An inlet port and an outlet port are formed in an inner wall face of the main passage. An upstream end of the bypass passage is connected with the inlet port, and a downstream end of the bypass passage is connected with the outlet port. A main valve for opening and closing the main passage is provided in the main passage. The main valve is disposed between the inlet port and the outlet port. A bypass valve for opening and closing the bypass passage is provided in the bypass passage. When the bypass valve is opened, the exhaust gas at the upstream end of the main valve can flow along the bypass passage to the downstream end of the main valve.

In this exhaust pressure control valve, the pressure of the exhaust gas increases if the degree of opening of the main valve is restricted. The bypass valve opens when the pressure of the exhaust gas exceeds a predetermined value. When the bypass valve opens, the exhaust gas flows along the bypass passage. The pressure increase of the exhaust gas is thus restrained, and the pressure of the exhaust gas is maintained at the predetermined value. By contrast, if the degree of opening of the main valve is increased, the pressure of the exhaust gas decreases, the bypass valve closes, and the bypass passage is also closed.

Disclosure of Invention

[0004] In recent years, the aforementioned exhaust pressure control valve has been considered for application to a diesel particulate filter system (hereinafter referred to as DPF system) that cleans the exhaust gas discharged from a diesel engine. The DPF system is a system for catching particulates (particulate matter) or graphite included in the exhaust gas of the diesel engine by using a ceramic filter. In the DPF system, when the amount of particulate matter (PM) having soot as its main component caught in the filter exceeds a predetermined amount, the particulate matter (PM) having soot as its main component caught in the filter is burnt, thus reconditioning the filter. The exhaust pressure control valve is utilized to recondition the filter. That is, the exhaust pressure control valve is disposed upstream or downstream from the filter. When the filter is to be reconditioned, the degree of opening of the main valve is restricted and the pressure of the exhaust gas is increased. When the pressure of the exhaust gas exceeds a predetermined value, the bypass valve opens and the exhaust gas flows along the bypass passage. The pressure of the exhaust gas is thus maintained at the predetermined value. If the load on the engine increases due to an increase in the pressure of the exhaust gas, the amount of fuel fed to the engine is increased. As a result, the exhaust temperature increases and catalysts are activated, and a part of the fuel not burnt by the engine is fed to oxidation catalysts at the upstream end of the filter. The fuel fed to the oxidation catalysts increases the exhaust gas temperature within the catalyst due to an oxidation reaction, and the particulate matter (PM) having soot as its main component caught in the filter is burnt (i.e. the filter is reconditioned). When the reconditioning of the filter is completed, the main valve is opened, and the pressure of the exhaust gas falls to its normal pressure. The pressure of the exhaust gas is thus controlled by the exhaust pressure control valve, whereby the reconditioning of the filter can be performed utilizing the fuel fed to the engine.

However, in the case where the exhaust pressure control valve is applied to the DPF system, when the main valve is to be switched from a closed state (this includes a state where the degree of opening of the main valve is restricted) to an open state when the reconditioning of the filter is completed, the exhaust gas flows abruptly from the upstream end to the downstream end of the main valve. As a result, there is the problem that unpleasant noise (a blowing noise) is generated. In particular, the vehicle in which a diesel engine is mounted is frequently a large vehicle such as a bus, truck, etc., and consequently a large amount of noise is generated. Reducing the noise is consequently an important problem.

[0005] The aim of the present invention is to provide an exhaust pressure control valve capable of reducing the amount of noise generated when a main valve of the exhaust pressure control valve is switched from a closed state to an open state.

[0006] The present inventors performed flow analysis simulations of the exhaust gas in order to identify the cause of the noise generated when the main valve is switched from the closed state to the open state. As a result, they determined that when the main valve is switched from the closed state to the open state, the exhaust gas that is flowing rapidly from the upstream end to the downstream end of the main valve strikes against an outlet port, this causing turbulence in the exhaust gas within the outlet port, and this turbulence being a cause of the noise.

To deal with this, the exhaust pressure control valve of the present invention comprises a housing having a main passage and a bypass passage, a main valve for opening and closing the main passage, and a bypass valve for opening and closing the bypass passage. The main valve comprises a throttle shaft rotatably supported by the housing and a valve member attached to the throttle shaft. The rotation of the throttle shaft causes the valve member to switch between a closed state in which the valve member closes the main passage and an open state in which the valve member opens the main passage. An inlet port is formed in an inner wall face of the main passage at an upstream side of the main valve, and an upstream end of the bypass passage is connected with this inlet port. An outlet port is formed in the inner wall face of the main passage at a downstream end of the main valve, and a downstream end of the bypass passage is connected with this outlet port. When the main valve is in the closed state, the position of the outlet port is offset in the circumferential direction from the position of a point on the circumferential edge of the valve member at which the distance from an axis of the throttle shaft to the circumferential edge of the valve member is longest. When the main valve is opened from the closed state, a space between the circumferential edge of the valve member and the main passage becomes largest at the point on the circumferential edge of the valve member at which the distance from the axis of the throttle shaft to the circumferential edge of the valve member is longest (i.e. a point at which the rotational radius is at its greatest), and the flow speed of the exhaust gas becomes fastest at this point. In this exhaust pressure control valve, there is a deviation in the circumferential direction between the position of the outlet port and the position of the point on the circumferential edge of the valve member at which the distance from the axis of the throttle shaft to the circumferential edge of the valve member is longest. As a result, the center of the rapid exhaust gas flow that occurs when the main valve is closed is offset in position from the outlet port. It is thereby possible to suppress the generation of sound when the main valve is closed.

[0007] In the aforementioned exhaust pressure control valve, it is preferred that the position of the outlet port in the circumferential direction is substantially identical to the position in the circumferential direction of a part supporting the throttle shaft provided in the main passage.

According to this configuration, the outlet port is disposed in a position apart from the rapid exhaust gas flow, and consequently the generation of noise can be suppressed effectively.

[0008] Further, it is preferred that the exhaust pressure control valve further comprises a bearing housed in a through hole formed in the housing and supporting one end of the throttle shaft, an actuator connected to one end of the throttle shaft that protrudes toward the exterior of the housing from the through hole and that drives the rotation of the throttle shaft, and a seal member that seals between the throttle shaft and an inner wall face of the through hole.

According to this configuration, the rotation of the throttle shaft can be performed smoothly, and it is possible to suppress the flow of exhaust gas from the main passage.

[0009] Further, it is preferred that a flow characteristic changing means is provided in the outlet port, this flow characteristic changing means changing the flow characteristics of the exhaust gas. When the flow characteristic changing means is provided in the outlet port, the occurrence of turbulence in the exhaust gas within the outlet port is suppressed even if the exhaust gas is flowing rapidly toward the outlet port when the main valve is changed from the closed state to the open state. The occurrence of noise when the main valve is closed can thus be reduced.

Moreover, the flow characteristic changing means can be a wall face having a curved surface shape formed at a downstream side of the outlet port. That is, the occurrence of turbulence in the outlet port can be suppressed by forming the wall face at the downstream side of the outlet port in the curved surface shape.

Alternatively, the flow characteristic changing means can utilize a flow rectifying member attached to a wall face at a downstream side of the outlet port, this flow rectifying member rectifying the flow of exhaust gas. The occurrence of turbulence in the outlet port can also be suppressed by the flow rectifying member.

[0010] In the case where the exhaust pressure control valve is utilized in a DPF system, a space may be formed between the circumferential edge of the valve member and the inner wall face of the main passage. In this case, the pressurized exhaust gas upstream from the main valve flows rapidly towards the downstream side from the space between the circumferential edge of the valve member and the inner wall face of the main passage when the main passage is closed, and a blowing noise occurs.

As a result of examining flow analysis simulations to identify the cause of the blowing noise, it was determined that the main cause of the blowing noise was the difference in flow speed between the exhaust gas flowing rapidly from the upstream side of the valve and the surroundings of this exhaust gas flow. Consequently, if the flow speed of the exhaust gas could be reduced when flowing from the upstream side to the downstream side of the valve, the difference in flow speed would also be reduced, and the blowing noise could be reduced.

Moreover, in order to reduce the blowing noise, exhaust pressure control valves have been provided with a communication hole (the communication hole passing from a front surface to a back surface) in the valve member of the main valve (for example, Japanese Patent Application Publication No. 2005-299457). The amount of flow of the exhaust gas flowing through the space between the circumferential edge of the valve member and the inner wall face of the main passage is reduced by providing the communication hole in the valve member, and consequently the noise can be somewhat reduced. In the conventional technique, however, the communication hole provided in the valve member extends parallel to the direction in which an exhaust passage extends. As a result, the flow direction of the exhaust gas flowing toward the downstream side from the circumferential edge of the valve member is parallel to (the same as) the flow direction of the exhaust gas flowing toward the downstream side from the communication hole, and it is thus difficult for the two flows to mix together. There is consequently not a sufficient reduction in the difference in flow speed between the flow of exhaust gas that is flowing rapidly from the upstream side of the main valve and the flow speed of the surrounding exhaust gas, and the occurrence of the blowing noise could not be reduced sufficiently.

To deal with this, in one aspect of an exhaust pressure control valve of the present invention, a space is formed, along the entire circumference of the circumferential edge of the valve member, between the circumferential edge of the valve member and the inner wall face of the main passage when the valve is in the closed state, and a communication hole is formed in the valve member that passes from a front surface to a back surface thereof. The communication hole is formed such that, when the main valve is in the closed state, the flow direction of exhaust gas flowing out from the communication hole is oblique with respect to the axial direction of the main passage.

According to this configuration, the flow of the exhaust gas flowing toward the downstream side from the circumferential edge of the valve member is not parallel to the flow of the exhaust gas flowing from the communication hole, and it is consequently easy for the two flows to mix together. As a result, the flow speed of the exhaust gas that is flowing from the upstream side to the downstream side of the main valve is reduced. The occurrence of the blowing noise when the main valve is in the closed state can thereby be reduced.

[0011] The exhaust pressure control valve can be configured such that, when the valve is in the closed state, the surface of the valve member is oblique with respect to the axial direction of the main passage. In this case, it is preferred that the communication hole is formed in a position in the surface face of the valve member at a downstream side from the throttle shaft and is formed in a direction substantially perpendicular to the surface of the valve member.

According to this configuration, the exhaust gas flowing out from the communication hole flows toward the center of the exhaust passage. As a result, the exhaust gas disperses through the entirety of the exhaust passage, and consequently the flow speed of the exhaust gas can be reduced effectively. The effect of reducing the blowing noise can thereby be effectively increased.

[0012] Further, in the aforementioned exhaust pressure control valve, it is preferred that a gas flow speed reducing means (for example, wire gauze, or the like) is provided at the inner wall face of the main passage at a downstream side from the main valve, this gas flow speed reducing means reducing the flow speed of the exhaust gas near the inner wall face. Since the flow speed is reduced of the exhaust gas flowing downstream from between the circumferential edge of the valve member and the inner wall face of the exhaust passage, the blowing noise can be further reduced.

[0013] Furthermore, the present invention provides an exhaust pressure control valve capable of reducing the occurrence of noise when the main valve is switched from the closed state to the open state. The exhaust pressure control valve comprises a housing having a main passage and a bypass passage, a main valve for opening and closing the main passage, a first valve opening and closing device for driving the opening and closing of the main valve, a bypass valve for opening and closing the bypass passage, and a second valve opening and closing device for driving the opening and closing of the bypass valve. The first valve opening and closing device is set such that the time for the main valve to change from a closed state to an open state is longer than the time for the main valve to change from the open state to the closed state. As a result it is possible to suppress the rapid flow of exhaust gas from the upstream side to the downstream side of the main valve when the main valve is changed from the closed state to the open state. The noise (the blowing noise) can thereby be reduced. Further, since the time for the main valve to change from the open state to the closed state is set to be short, it is possible to increase the pressure of the exhaust gas to a desired value within a short period.

[0014] In the aforementioned exhaust pressure control valve, the first valve opening and closing device can be operated by, for example, a solenoid, air, oil pressure, etc. and the first valve opening and closing device drives the opening and closing in accordance with the driving state of the engine. Further, the second valve opening and closing device can utilize, for example, a diaphragm type actuator, and drives the opening and closing in accordance with the pressure of the exhaust gas upstream from the main valve.

In this case, the first valve opening and closing device can comprise a diaphragm type actuator for driving the opening and closing of the main valve, a discharging and feeding means for discharging gas from and feeding gas to a pressure chamber of the actuator, a pipe connecting the discharging and feeding means and the pressure chamber of the actuator, and a flow amount regulating means disposed on the pipe, this flow amount regulating means switching between a first state in which the cross-sectional area of a through opening through which gas passes is large and a second state in which the cross-sectional area of the through opening through which gas passes is small. The actuator is set so as to close the main valve when the pressure of gas within the pressure chamber exceeds a predetermined pressure, and so as to open the main valve when the pressure of the gas within the pressure chamber is equal to or below the predetermined pressure. The flow amount regulating means is put in the first state when gas is to be discharged from the pressure chamber, and is put in the second state when gas is to be fed to the pressure chamber.

According to this configuration, the main valve changes from the closed state to the open state when the pressure in the pressure chamber of the diaphragm type actuator exceeds the predetermined pressure due to gas being fed to the pressure chamber. Since the flow amount regulating means causes the cross-sectional area of the gas through opening to be small when the gas is fed to the pressure chamber, a rapid increase in the pressure in the pressure chamber is suppressed. As a result, the main valve changes slowly to the open state. By contrast, the main valve changes from the open state to the closed state when the pressure in the pressure chamber of the diaphragm type actuator reaches or falls below the predetermined pressure due to gas being discharged from the pressure chamber. Since the flow amount regulating means causes the cross-sectional area of the gas through opening to be large when gas is discharged from the pressure chamber, the pressure of the pressure chamber falls rapidly. As a result, the main valve changes quickly to the closed state.

[0015] Further, it is preferred that the second valve opening and closing device comprises a movable member that moves linearly in accordance with the pressure of exhaust gas at an upstream side of the main valve, and a link mechanism that converts the linear movement of the movable member into opening and closing movement of the bypass valve.

According to this configuration, the linear movement of the movable member that is in accordance with the pressure of the exhaust gas is transmitted to the bypass valve via the link mechanism. As a result, even in the case where the pressure of the exhaust gas is pulsating, the pulsation is diffused by the buffering effect of the diaphragm, and consequently the behavior of the bypass valve can be made more stable. The pressure of the exhaust gas can thereby be controlled accurately.

[0016] Further, the second valve opening and closing device may comprise, for example, a housing chamber for housing the movable member, an inlet pipe for leading the exhaust gas from the upstream side of the main valve into one of housing chambers divided by the movable member, and a biasing means disposed in the other of the housing chambers. The biasing means biases the movable member toward the one housing chamber.

According to this configuration, the position of the movable member changes in accordance with the pressure of the exhaust gas. As a result, the degree of opening of the bypass valve can change in accordance with the pressure of the exhaust gas. The pressure of the exhaust gas can thereby be controlled accurately.

[0017] Further, it is preferred that a connecting hole to which a DPF device can be connected is provided at an upstream end of the housing.

According to this configuration, the exhaust pressure control valve is disposed at a downstream side of the DPF device. As a result, the exhaust gas which has had the particulate matter (PM) having soot as its main component removed by the DPF device flows through the exhaust pressure control valve. As a result, it is possible to prevent the particulate matter (PM) having soot as its main component, etc. from adhering to the exhaust pressure control valve and causing a deterioration in the controlling ability of the exhaust pressure control valve.

[0018] Further, a flange part to which an exhaust pipe is attached can be formed at a downstream end of the housing. In this case, it is preferred that the flange part is joined flexibly to the exhaust pipe.

It is possible to prevent vibration of a device (for example, an engine or the like) at an upstream side of the exhaust pressure control valve from being transmitted to the exhaust pipe by joining the exhaust pressure control valve and the exhaust pipe flexibly.

[0019] Further, it is preferred that the bypass valve is disposed at a central part of the bypass passage at a position apart from the main passage. It is preferred that the second valve opening and closing device comprises a movable member that moves linearly in accordance with the pressure of exhaust gas at an upstream side of the main valve, and a link mechanism that converts the linear movement of the movable member into opening and closing movement of the bypass valve.

According to this configuration, since the bypass valve is provided at the central part of the bypass passage (i.e. at the position apart from the main passage), the pressure of the exhaust gas flowing along the main passage is prevented from having a direct affect on the bypass valve. Furthermore, the opening and closing of the bypass valve is performed by causing the linear movement of the movable member to be in accordance with the pressure of the exhaust gas at the upstream side of the main valve, and by transmitting the linear movement of the movable member to the bypass valve via the link mechanism. As a result, even if the exhaust gas flowing along the main passage is pulsating and the pressure of the exhaust gas at the upstream side of the main valve changes slightly, this configuration prevents the opening and closing of the bypass valve from being greatly affected thereby. Chattering of the bypass valve can thereby be prevented, and the pressure of the exhaust gas can be controlled stably.

Brief Description of the Drawings

[0020]

FIG. 1 shows the configuration of an exhaust system of a diesel engine in which an exhaust pressure control valve of the first embodiment is mounted.

FIG. 2 shows a cross-sectional view showing the schematic configuration of the exhaust pressure control valve of the first embodiment.

FIG. 3 shows a cross-sectional view along the line III-III of FIG. 2.

FIG. 4 shows a figure for explaining the positions in the circumferential direction of an inlet port, an outlet port, and a bearing portion of a throttle shaft.

FIG. 5 schematically shows the configuration of a device for opening and closing a main valve.

FIG. 6 schematically shows the configuration of a device for opening and closing a bypass valve.

FIG. 7 is a figure showing the state of a flow amount regulating valve when closing the main valve.

FIG. 8 is a figure schematically showing changes over time in a three way electromagnetic valve, the pressure of a pressure chamber of an actuator, and the degree of opening of the main valve.

FIG. 9 is a figure showing an example of results measuring changes in exhaust pressure and changes in the sound pressure of a blowing noise when the main valve changes from the closed state to the open state.

FIG. 10 is a figure showing the relationship between a response period of the main valve (the period for the main valve to change from the closed state to the fully open state) and the sound pressure (maximum sound pressure) of the blowing noise.

FIG. 11 is a figure showing a variant of a configuration for attaching the exhaust pressure control valve to an exhaust pipe.

FIG. 12 is a figure showing a variant of the exhaust pressure control valve of the first embodiment.

FIG. 13 is a figure showing another variant of the exhaust pressure control valve of the first embodiment.

FIG. 14 is a figure showing another variant of the exhaust pressure control valve of the first embodiment.

FIG. 15 is a figure showing an enlargement of an outlet port of the exhaust pressure control valve shown in FIG. 14.

FIG. 16 is a partially fragmented perspective view of another exhaust pressure control valve of the present invention.

FIG. 17 is a partially fragmented perspective view of the exhaust pressure control valve shown in FIG. 16 seen from another direction.

FIG. 18 is a figure seen from a bypass passage side of an inlet port 116, an outlet port 146, and a throttle shaft 132 of the exhaust pressure control valve shown in FIG. 16.

FIG. 19 is a figure showing an enlargement of a connecting part of the inlet port 116 and a main passage 112.

FIG. 20 is a figure showing only a main passage and a main valve taken from an exhaust pressure control valve of a second embodiment.

FIG. 21 is a figure showing an enlargement of a circumferential edge of a valve member and an inner wall face of the main passage.

FIG. 22 is a figure showing the results of a flow simulation of the exhaust pressure control valve of the second embodiment.

FIG. 23 is a figure showing the results of a flow simulation in the case where a communication hole is not provided.

FIG. 24 is a figure showing the results of a flow simulation of a variant of the second embodiment.

Best Mode for Carrying Out the Invention

[0021] Preferred features of the present invention will be described below.

(Feature 1) The exhaust pressure control valve is disposed in an exhaust passage of a diesel engine. A DPF device is connected upstream from the exhaust pressure control valve, and an exhaust pipe (muffler) is connected downstream from the exhaust pressure control valve.

(Feature 2) The exhaust pressure control valve comprises a housing provided with a main passage and a bypass passage. The bypass passage is adjacent to the main passage. In the main passage, an inlet port is formed at an upstream side of a main valve and an outlet port is formed at a downstream side of the main valve. An upstream end of the bypass passage is connected to the main passage via the inlet port, and a downstream end of the bypass passage is connected to the main passage via the outlet port. A bypass valve is disposed in the center of the bypass passage.

(Feature 3) An opening and closing device for opening and closing the bypass valve comprises a diaphragm type actuator and a link mechanism that converts the linear movement of a rod of the actuator into opening and closing movement of the bypass valve.

(Feature 4) An opening and closing device for opening and closing the main valve comprises a diaphragm type actuator. The main valve opens when the pressure of a pressure chamber of the actuator exceeds a predetermined pressure, and the main valve closes when the pressure of the pressure chamber of the actuator becomes less than or equal to the predetermined pressure. The pressure chamber of the actuator is connected to a central port of a three way electromagnetic valve, one of two remaining ports of the three way electromagnetic valve is connected to a vacuum pump, and the other port is open to the atmosphere. A flow amount regulating valve is provided between the three way electromagnetic valve and the pressure chamber of the actuator.

(Feature 5) The flow amount regulating valve has a housing, and a dividing plate that divides the interior of the housing into an actuator side and a three way electromagnetic valve side. A plurality of orifices are formed in the dividing plate, and a part of the plurality of orifices is opened and closed by a valve member (valve). The valve member closes the orifices when air is to be led into the pressure chamber of the actuator, and opens the orifices when air is to be discharged from the pressure chamber of the actuator.

(Feature 6) The main valve has a throttle shaft, and a valve member attached to the throttle shaft. Both ends of the throttle shaft are supported by the housing in a manner allowing rotation. The rotation of the throttle shaft causes the valve member to switch between a closed state in which the valve member closes the main passage, and an open state in which the valve member opens the main passage. The valve member is oblique with respect to the axial direction of the main passage when the main valve changes to the closed state.

(Feature 7) The position of the outlet port in the circumferential direction is identical to the position in the circumferential direction of a point (i.e. a supporting part that supports the throttle shaft) on the circumferential edge of the valve member at which the distance from an axis of the throttle shaft to the circumferential edge of the valve member is shortest. A wall face at the downstream side of the outlet port is chamfered into a curved surface shape (an R shape).

(Feature 8) A flow rectifying member (a cover plate, a fin, a honeycomb, etc.) is disposed at the wall face at the downstream side of the outlet port.

(Feature 9) An inlet port is formed parallel to the throttle shaft. The inlet port is formed in a position that is offset in the circumferential direction from the supporting part that supports the throttle shaft. Parts of the inlet port and the throttle shaft overlap in the axial direction of the main passage.

(Feature 10) A space is formed along the entire circumference between the circumferential edge of the valve member and the inner wall face of the main passage when the main valve is changed to the closed state, and the main valve is oblique with respect to the axial direction of the main passage.

(Feature 11) The exhaust pressure control valve comprises a housing having a main passage and a bypass passage, a main valve having a throttle shaft rotatably supported by the housing and a valve member attached to the throttle shaft, and a bypass valve for opening and closing the bypass passage. This main valve switches, by means of causing the throttle shaft to rotate, between a closed state in which the valve member closes the main passage and an open state in which the valve member opens the main passage. An inlet port is formed in an inner wall face of the main passage at an upstream side of the main valve, this inlet port connecting to an upstream end of the bypass passage. An outlet port is formed in the inner wall face of the main passage at a downstream side of the main valve, this outlet port connecting to a downstream end of the bypass passage. A flow characteristic changing means that changes the flow characteristics of the exhaust gas is provided on the outlet port.

(Feature 12) The exhaust pressure control valve comprises a housing having an exhaust passage, and a valve provided with a rotation shaft rotatably supported by the housing and a valve member attached to the rotation shaft. The valve switches, by means of causing the rotation shaft to rotate, between a closed state in which the valve member closes the exhaust passage and an open state in which the valve member opens the exhaust passage. A communication hole is formed in the valve member and passes from a front surface to a back surface thereof. The communication hole is formed such that, when the valve is in the closed state, the flow direction of exhaust gas flowing out from the communication hole is oblique with respect to the axial direction of the exhaust passage.

(Feature 13) The exhaust pressure control valve comprises a housing having an exhaust passage, a valve having a rotation shaft rotatably supported by the housing and a valve member attached to the rotation shaft, and a gas flow speed reducing means formed at an inner wall face of the exhaust passage at a downstream side from the valve. The valve switches, by means of causing the rotation shaft to rotate, between a closed state in which the valve member closes the exhaust passage and an open state in which the valve member opens the exhaust passage. The gas flow speed reducing means reduces the flow speed of the exhaust gas near the inner wall face.

(Feature 14) The exhaust pressure control valve comprises a housing having a main passage and a bypass passage, a main valve for opening and closing the main passage, a first valve opening and closing device for driving the opening and closing of the main valve, a bypass valve for opening and closing the bypass passage, and a second valve opening and closing device for driving the opening and closing of the bypass valve. The bypass valve is disposed at a central part of the bypass passage at a position apart from the main passage. The second valve opening and closing device comprises a movable member that moves linearly in accordance with the pressure of exhaust gas at an upstream side of the main valve, and a link mechanism that converts the linear movement of the movable member into opening and closing movement of the bypass valve.

(First Embodiment)

[0022] A first embodiment in which the present invention is realized will be described with reference to figures. First, the configuration will be described of an exhaust system of a diesel engine 1 in which an exhaust pressure control valve 10 of the present embodiment is mounted. As shown in FIG. 1, the exhaust system of the diesel engine 1 comprises a DPF device 3 and the exhaust pressure control valve 10. The DPF device 3 has a filter (manufactured from ceramic) that catches particulate matter (PM) having soot as its main component that is included in the exhaust gas. The diesel engine 1 is connected to an upstream end of the DPF device 3 via an exhaust pipe 2. The exhaust pressure control valve 10 is connected via an exhaust pipe 5 to a downstream end of the DPF device 3. A pressure sensor 2a is disposed in the exhaust pipe 2. The pressure sensor 2a detects the pressure of the exhaust gas flowing through the exhaust pipe 2. A pressure sensor 5a is disposed in the exhaust pipe 5. The pressure sensor 5a detects the pressure of the exhaust gas flowing through the exhaust pipe 5. The pressure of the exhaust gas detected by the pressure sensors 2a and 5a is input to an ECU 4 (an electronic control unit). The exhaust pressure control valve 10 controls the pressure of the exhaust gas discharged from the diesel engine 1. A downstream end of the exhaust pressure control valve 10 is connected to a muffler via an exhaust pipe 6. Control of the diesel engine 1 and the exhaust pressure control valve 10 is performed by the ECU 4. The ECU 4 controls the amount of air intake and amount of fuel fed to the diesel engine 1 in accordance with the driving state of the diesel engine 1. Further, when the pressure difference (i.e. pressure loss of the DPF device 3) between the pressures determined by the pressure sensors 2a and 5a exceeds a predetermined value, the ECU 4 closes a main valve (to be described later) of the exhaust pressure control valve 10, and reconditions the filter of the DPF device 3.

[0023] In the aforementioned exhaust system, the exhaust gas discharged from the diesel engine 1 flows to the DPF device 3 via the exhaust pipe 2. The DPF device 3 catches the particulate matter (PM) having soot as its main component included in the exhaust gas. The exhaust gas cleaned by the DPF device 3 is discharged to the outside air from the muffler via the exhaust pipe 5, the exhaust pressure control valve 10, and the exhaust pipe 6.

When the pressure loss of the DPF device 3 becomes large due to the DPF device 3 catching the particulate matter (PM) having soot as its main component, the ECU 4 closes the main valve of the exhaust pressure control valve 10. The exhaust pressure of the diesel engine 1 thereby increases, and the amount of fuel fed to the diesel engine 1 is increased in accordance with the increase in the exhaust pressure. As a result, gas that includes unburned components is fed to the DPF device 3. The gas that includes unburned components is fed to oxidation catalysts at an upstream end of the filter. The unburned components fed to the oxidation catalysts increase the exhaust gas temperature within the catalyst due to an oxidation reaction. The particulate matter (PM) having soot as its main component caught in the filter is thereby burnt (i.e. the filter of the DPF device 3 is reconditioned). When the reconditioning of the filter of the DPF device 3 is completed, the ECU 4 opens the main valve of the exhaust pressure control valve 10, and the normal operating state is returned to. Moreover, the reconditioning of the DPF device 3 is performed every time the pressure loss of the DPF device 3 exceeds the predetermined value.

[0024] Next, the exhaust pressure control valve 10 will be described. As shown in FIG. 2, the exhaust pressure control valve 10 comprises a housing 11 having a main passage 12 and a bypass passage 28, a main valve 10 for opening and closing the main passage 12, and a bypass valve 26 for opening and closing the bypass passage 28.

[0025] The housing 11 has the main passage 12 and the bypass passage 28 (bypass chamber) that is provided adjacent to the main passage 12. The exhaust pipe 5 is attached to an upstream end 14 of the main passage 12. The exhaust pipe 6 is attached via a connecting pipe 70 to a downstream end 66 of the main passage 12. An inlet port 16 and an outlet port 46 are formed in an inner wall face of the main passage 12. The inlet port 16 is formed at the upstream end 14 side, and the outlet port 46 is formed at the downstream end 66 side. The main valve 30 is disposed between the inlet port 16 and the outlet port 46. The main valve 30 opens and closes the main passage 12 between the inlet port 16 and the outlet port 46.

[0026] An upstream end of the bypass passage 28 is connected to the main passage 12 via the inlet port 16. A downstream end of the bypass passage 28 is connected to the main passage 12 via the outlet port 46. The bypass valve 26 is housed in the bypass passage 28. The bypass valve 26 opens and closes an opening portion from the inlet port 16 to the bypass passage 28. As is clear from the figures, the bypass valve 26 is disposed in a position that is away from the inner wall face of the main passage 12.

[0027] As shown in FIG. 4, a throttle shaft 32 of the main valve 30 passes through a center (point O) of the main passage 12, and both ends thereof are supported by a wall face (points A and C of the housing 11) of the main passage 12. As shown in FIG. 3, the position of the inlet port 16 in the circumferential direction is identical with the position in the circumferential direction of a bearing portion that supports one end of the throttle shaft 32 (point A or point C in FIG. 4). Like the inlet port 16, the position of the outlet port 46 in the circumferential direction is identical with the position in the circumferential direction of a bearing portion that supports one end of the throttle shaft 32. As a result, the main passage 12 and the bypass passage 28 extend substantially parallel to one another (axes thereof are parallel).

As shown in FIG. 3, the inlet port 16 is formed to have a round shape in cross-section. By having the inlet port 16 be round in cross-section, it is easier for the inlet port 16 to be closed (see FIG. 2) in an airtight manner by the bypass valve 26 (described later). By contrast, the outlet port 46 is formed to have a rectangular shape in cross-section. By having the outlet port 46 be rectangular in cross-section, the cross-sectional area of the passage of the outlet port 46 can be kept large, and the exhaust gas flows easily from the outlet port 46 to the main passage 12. Moreover, the inlet port 16 and the outlet port 46 are formed so as to be substantially orthogonal to the axis of the main passage 12 (i.e. the inlet port 16, the outlet port 46, and the throttle shaft 32 are parallel).

Further, as shown in FIG. 2, a portion of a wall face 48 at the downstream side of the outlet port 46 that is a portion connecting to the main passage 12 is chamfered to a curved surface shape (an R shape). The exhaust gas flowing along the main passage 12 thereby flows easily toward the downstream end 66.

[0028] As shown in FIG. 2, the main valve 30 is a butterfly type valve. The main valve 30 comprises the throttle shaft 32, and a valve member 34 attached to the throttle shaft 32. The rotation of the throttle shaft 32 causes switching between a closed state in which the valve member 34 closes the main passage 12 and an open state in which the valve member 34 opens the main passage 12. In the state where the valve member 34 has closed the main passage 12, the valve member 34 is oblique with respect to the axis (the central axis) of the main passage 12 (see FIG. 3). Furthermore, a clearance is formed between a circumferential edge of the valve member 34 and the inner wall face of the main passage 12. This clearance is formed so as to allow the diesel engine 1 to operate even when the main valve 30 has been closed. The clearance is formed along the entire circumference of the valve member 34.

[0029] One end of the throttle shaft 32 is supported in a manner allowing rotation by a bearing 40. The bearing 40 is housed in an attachment hole 42 formed in the housing 11. The attachment hole 42 is formed between the inlet port 16 and the outlet port 46. The throttle shaft 32 passes through one end of the attachment hole 42 (an end part at the main passage 12 side). The other end of the attachment hole 42 opens into the bypass passage 28, and this opening is closed by a cap 36. The particulate matter (PM) having soot as its main component that is in the exhaust gas is prevented from entering the attachment hole 42 by closing the opening of the attachment hole 42 using the cap 36.

Further, the other end of the throttle shaft 32 is supported in a manner allowing rotation by a bearing 54. The bearing 54 is housed in an attachment hole 52 formed in the housing 11. The throttle shaft 32 passes through one end of the attachment hole 52 (an end part at the main passage 12 side). A seal ring 50 is disposed between the throttle shaft 32 and the attachment hole 52. The exhaust gas within the main passage 12 is prevented from flowing out to the exterior by the seal ring 50. The other end of the attachment hole 42 is open to the exterior, and a driving end 32b of the throttle shaft 32 protrudes to the exterior from this opening. The driving end 32b of the throttle shaft 32 is coupled to a rod 60 of an actuator 64 via a coupling part 62. The throttle shaft 32 is made to rotate by means of the rod 60 expanding.

[0030] Next, an opening and closing device 41 that opens and closes the main valve 30 will be described with reference to FIG. 5. As shown in FIG. 5, the opening and closing device 41 comprises the actuator 64, a three way electromagnetic valve 47, and a vacuum pump 43. The actuator 64 is a diaphragm type actuator. The actuator 64 comprises the rod 60 that moves in accordance with pressure of a pressure chamber (not shown). One end of the coupling part 62 is attached in a manner allowing rotation to an anterior end of the rod 60. The driving end 32b of the throttle shaft 32 is attached to the other end of the coupling part 62. When the rod 60 moves, the throttle shaft 32 rotates in response thereto, and the main valve 30 is thereby switched between the open state in which the main passage 12 is open and the closed state in which the main passage 12 is closed. That is, the main valve 30 opens the main passage 12 when the pressure in the pressure chamber of the actuator 64 exceeds a predetermined pressure, and the main valve 30 closes the main passage 12 when the pressure in the pressure chamber of the actuator 64 falls to or below the predetermined pressure.

[0031] The pressure chamber of the actuator 64 is connected to a central port 47c of the three way electromagnetic valve 47 via piping 57a, a flow amount regulating valve 51, and piping 57b. A first port 47a, out of two remaining ports 47a and 47b of the three way electromagnetic valve 47 is connected to the vacuum pump 43 via a check valve 45. The other port 47b of the three way electromagnetic valve 47 is open to the atmosphere. The check valve 45 prevents the reverse flow of air from the vacuum pump 43 toward the three way electromagnetic valve 47.

The three way electromagnetic valve 47 is controlled by the ECU 4. If the vacuum pump 43 is operated in the state where the port 47b is closed and the central port 47c and the port 47a communicate, the air within the pressure chamber of the actuator 64 is discharged (the main valve 30 thereby assuming the closed state). By contrast, in the state where the port 47a is closed and the central port 47c and the port 47b communicate, outside air is led into the pressure chamber of the actuator 64 (the main valve 30 thereby assuming the open state).

[0032] The flow amount regulating valve 51 is disposed between the pressure chamber of the actuator 64 and the three way electromagnetic valve 47. The flow amount regulating valve 51 has a housing 51, a dividing wall 53 formed at a center of the housing 51, and a valve member 55 attached to the dividing wall 53. A first room 51a formed by being divided by means of the dividing wall 53 communicates with the pressure chamber of the actuator 64 via the piping 57a. An other room 51 b formed by being divided by means of the dividing wall 53 is connected to the central port 47c of the three way electromagnetic valve 47 via the piping 57b.

A plurality of orifices (through holes) 53 a are formed in the dividing wall 53. A part of the plurality of orifices 53a is opened and closed by the valve member 55. That is, when air is to be led into the pressure chamber of the actuator 64 (when the air flows from the three way electromagnetic valve 47 toward the actuator 64), the valve member 55 closes a part of the orifices of the dividing wall 53. When air is to be discharged from the pressure chamber of the actuator 64 (when the air flows from the actuator 64 toward the three way electromagnetic valve 47), the valve member 55 changes shape and opens the orifices 53a of the dividing wall 53 (the state shown in FIG. 7). As a result, the cross-sectional area through which the air passes becomes smaller when the air is led into the pressure chamber of the actuator 64, and the air is thus fed slowly to the pressure chamber of the actuator 64. By contrast, the cross-sectional area through which the air passes becomes larger when the air is discharged from the pressure chamber of the actuator 64, and the air is thus discharged rapidly from the pressure chamber of the actuator 64. The time for the main valve 30 to pass from the closed state to the open state is thus adjusted to be longer than the time for the main valve 30 to pass from the open state to the closed state.

[0033] The bypass valve 26 is a flap valve. The bypass valve 26 has a valve member 24, and a bolt 22 for attaching the valve member 24 to an arm 20. As shown in FIG. 6, an opening and closing device 69 for opening and closing the bypass valve 26 comprises an actuator 79, and link mechanisms (73, 20) that transmit the movement of the actuator 79 to the bypass valve 26.

The actuator 79 is a diaphragm type actuator. The actuator 79 comprises a cylinder 81 and a rod 75. The rod 75 has a dividing wall part 75a formed at a base end part thereof, and a rod part 75b rising from the dividing wall part 75a. The dividing wall part 75a is housed within the cylinder 81 in a manner allowing movement, and demarcates a pressure chamber 77 and a spring housing chamber 83 within the cylinder 81. The pressure chamber 77 communicates with the exhaust pipe 5 via an exhaust gas inlet pipe 23, such that exhaust gas flowing along the exhaust pipe 5 is led into the pressure chamber 77. A spring 85 is housed in a compressed state within the spring housing chamber 83. The spring 85 pushes the dividing wall part 75a toward the pressure chamber 77. A base end of a link 73 is attached to an anterior end of the rod part 75b so as to be capable of rotating. One end of the arm 20 is fixed to an anterior end of the link 73. The bypass valve 26 is attached to the other end of the arm 20.

When the pressure of the exhaust gas led into the pressure chamber 77 is equal to or below a predetermined pressure, the pushing force of the spring 85 on the dividing wall part 75a is greater than the force exerted on the dividing wall part 75a by the exhaust gas within the pressure chamber 77. As a result, the rod 75 is in an initial position, and the bypass valve 26 is closing the bypass passage 28. By contrast, when the pressure of the exhaust gas led into the pressure chamber 77 exceeds the predetermined pressure, the rod 75 moves in opposition to the pushing force of the spring 85. The arm 20 thereby rotates around an axis 18, and the bypass valve 26 attached to the anterior end of the arm 20 opens the bypass passage 28.

[0034] The operation of the exhaust pressure control valve 10 described above when opening and closing the main valve 30 will be described. First, the operation for changing the main valve 30 from the open state to the closed state will be described. Moreover, as is clear from the above description, atmospheric air is led into the pressure chamber of the actuator 64 when the main valve 30 is in the open state.

The opening and closing of the exhaust pressure control valve 10 is controlled by the ECU 4. The ECU 4 first outputs a driving signal to the three way electromagnetic valve 47, whereby the port 47b is closed and the central port 47c and the port 47a are caused to be in a communicating state. The port 47a communicates with negative pressure created by the vacuum pump 43. The air within the pressure chamber of the actuator 64 is thus discharged, and the main valve 30 closes the main passage 12. When the air is discharged from the pressure chamber of the actuator 64, the valve member 55 of the flow amount regulating valve 51 opens the orifices 53a. The air within the pressure chamber of the actuator 64 is consequently discharged rapidly.

[0035] Since the pressure of the exhaust gas increases when the main valve 30 closes the main passage 12, the pressure also increases of the exhaust gas led into the pressure chamber 77 of the actuator 79 that drives the bypass valve 26. When the pressure of the exhaust gas within the pressure chamber 77 exceeds the predetermined pressure, the rod 75 moves in opposition to the pushing force of the spring 85. The bypass valve 26 thereby opens the bypass passage 28. Moreover, the degree of valve opening of the bypass valve 26 is determined by the pressure of the exhaust gas within the exhaust pipe 5, being greater when the pressure of the exhaust gas within the exhaust pipe 5 is high, and being smaller when the pressure of the exhaust gas within the exhaust pipe 5 is low. The pressure of the exhaust gas within the exhaust pipe 5 is thus maintained at a substantially constant pressure.

Since the bypass valve 26 is disposed at a position apart from the inner wall face of the main passage 12, the bypass valve 26 is not directly affected by the exhaust pressure of the exhaust gas flowing along the main passage 12. Further, the opening and closing of the bypass valve 26 is performed by transmitting linear movement of the actuator 79 to the arm 20 via the link mechanisms. As a result, the behavior of the bypass valve 26 is stable even in the case where the exhaust gas flowing along the exhaust pipe 5 is pulsating, and chattering of the bypass valve 28 can thus be prevented. The controllability of the exhaust pressure is thus increased.

[0036] Next, the operation for changing the main valve 30 from the closed state to the open state will be described. When the main valve 30 is to be changed from the closed state to the open state, the ECU 4 outputs a driving signal to the three way electromagnetic valve 47, whereby the port 47a is closed and the central port 47c and the port 47b are caused to be in a communicating state. Atmospheric air is thus led from the three way electromagnetic valve 47 side into the pressure chamber of the actuator 64, and the main valve 30 opens the main passage 12. When the air is led into the pressure chamber of the actuator 64, the valve member 55 of the flow amount regulating valve 51 closes a part of the orifices 53a. As a result, air is led slowly into the pressure chamber of the actuator 64, and the main valve 30 opens slowly.

[0037] FIG. 8 is a figure that schematically shows the change in state of: the three way electromagnetic valve 47 that is transitioning from the state where the main valve 30 is closed to the state where the main valve 30 is open, the change in pressure in the pressure chamber of the actuator 64, and the change in the degree of valve opening of the main valve 30.

As shown in FIG. 8, the three way electromagnetic valve 47 is first switched from a negative pressure state (a state in which the actuator 64 and the vacuum pump 43 are connected) to a state of being open to the atmosphere (a state in which the actuator 64 is open to the atmosphere). When the three way electromagnetic valve 47 is switched to the state of being open to the atmosphere, the pressure chamber of the actuator 64 gradually transitions from a negative pressure state to an atmospheric pressure state. The main valve 30 starts to open gradually after a certain time lag t has passed from the time when the three way electromagnetic valve 47 switched to the state of being open to the atmosphere. The main valve 30 is fully open after a time t0 has passed from the time when the three way electromagnetic valve 47 switched to the state of being open to the atmosphere.

[0038] When the main valve 30 changes from the closed state to the open state, the exhaust gas flows from the upstream side to the downstream side of the main valve 30. In the initial period where the main valve 30 is beginning to open, the size of a space between the circumferential edge of the valve member 34 and the inner wall face of the main passage 12 is proportional to a distance (a rotational radius) from the axis of the throttle shaft 32 to the valve member 34 (to a point on the circumferential edge). That is, the space is largest at points B and D where the distance from the axis of the throttle shaft 32 to the valve member 34 (to a point on the circumferential edge) is longest (see FIG. 4). Conversely, the space is smallest at points A and C where the distance from the axis of the throttle shaft 32 to the valve member 34 (to the point on the circumferential edge) is shortest. As a result, the flow speed of the exhaust gas flowing out from the main valve 30 is fastest at points B and D, and is slowest at points A and C. The outlet port 46 is provided at the point A (or the point C), and is thus disposed at a position apart from the position where the exhaust gas is flowing out rapidly. For this reason the occurrence of turbulence within the outlet port 46 caused by the exhaust gas flowing out rapidly when the main valve 30 is opened is prevented, and the occurrence of noise can be prevented. Further, since the wall face 48 at the downstream side of the outlet port 46 is formed in a curved surface shape, the exhaust gas flowing out from the main valve 30 can flow smoothly toward the downstream end 66. Turbulence within the outlet port 46 is prevented from occurring by this, as well, and the occurrence of noise can thus be suppressed. Furthermore, since the main valve 30 is opened slowly, the rapid flow of exhaust gas toward the downstream side of the main valve 30 can be suppressed. This, also, can suppress the occurrence of noise.

Moreover, the pressure of the exhaust gas flowing along the exhaust pipe 5 decreases when the main valve 30 opens the main passage 12. As a result, the bypass valve 26 closes the bypass passage 28.

[0039] Further, in the present embodiment, the main valve 30 is transitioned gradually from the closed state to the open state by providing the opening and closing device 41 that opens and closes the main valve 30 with a flow amount regulating valve 49. The sound pressure of the noise (the blowing noise) that occurs is thereby reduced.

FIG. 9 shows an example of results measuring changes in the exhaust pressure and changes in the sound pressure of the blowing noise when the main valve 30 changes from the closed state to the open state. Moreover, FIG. 9 also shows, for comparison, the changes in exhaust pressure when the flow amount regulating valve 49 is not provided.

As is clear from FIG. 9, the change in pressure of the exhaust gas ($\Delta P/dt$) is more gradual in the case where the flow amount regulating valve 49 is provided than in the case where the flow amount regulating valve 49 is not provided, and the period (i.e., response period) for the main valve 30 to change from the closed state to the fully open state becomes longer. Further, as is clear from comparing the waveform of the change in pressure of the exhaust gas with the waveform of the change in the sound pressure of the blowing noise, there is a correlation between the size of the change in pressure of the exhaust gas and the sound pressure of the blowing noise (the amplitude of the sound pressure). As a result, the blowing noise is decreased by making the change in pressure of the exhaust gas gradual. That is, in the present embodiment, the blowing noise can be reduced by lengthening the response period of the main valve 30.

[0040] FIG. 10 is a figure showing the relationship between the response period of the main valve 30 (the period for the main valve 30 to change from the closed state to the fully open state) and the sound pressure (maximum sound pressure) of the blowing noise. As is clear from the figure, the maximum sound pressure of the blowing noise is reduced by lengthening the response period of the main valve 30.

[0041] In the exhaust pressure control valve 10 of the present embodiment, the position of the outlet port 46 in the circumferential direction is identical with the position in the circumferential direction of the shaft bearing portion of the throttle shaft 32, and the wall face 48 at the downstream side of the outlet port 46 is formed in a curved surface shape. The occurrence of turbulence in the exhaust gas within the outlet port 46 is thereby suppressed, and noise can effectively be prevented from occurring.

Further, the response period for the main valve 30 to change from the closed state to the fully open state is made longer by providing the opening and closing device 42 that opens and closes the main valve 30 with the flow amount regulating valve 49. As a result, the blowing noise is mitigated when the main valve 30 changes from the closed state to the open state. By contrast, the filter reconditioning of the DPF device 3 can be realized without time delays since the period for the main valve 30 to change from the open state to the closed state is set to be short.

Further, the bypass valve 26 is disposed in a position apart from the main passage 12, and the expanding and contracting movement of the rod of the actuator 79 is converted by the link mechanism into the opening and closing movement of the bypass valve 26. Since the pulsation pressure is diffused by the buffering effect of the diaphragm of the actuator, chattering of the bypass valve 26 can be prevented even in the case where the exhaust gas is pulsating in the exhaust pipe 5, and it is possible to control the exhaust pressure to within a predetermined pressure range. Further, since the degree of opening of the bypass valve 26 changes in accordance with changes in the pressure of the exhaust gas, it is possible to perform the filter reconditioning of the DPF device 3 even when the motor vehicle is in a running state (a state in which the flow amount (pressure) of the exhaust gas changes).

[0042] In the embodiment described above, the movement of the actuator 79 was transmitted to the bypass valve 26 via the link mechanism. However, the present invention is not restricted to this configuration. For example, the movement of the actuator may be converted into the opening and closing movement of the bypass valve utilizing a rack and pinion mechanism. With this type of configuration, as well, it is possible to regulate the degree of opening of the bypass valve in accordance with the exhaust pressure.

Further, in the embodiment described above, the connecting pipe 70 (exhaust pipe 6) is attached to the downstream end 66 of the main passage 12 in a manner where relative movement is not possible. However, the present invention is not restricted to this configuration. For example, as shown in FIG. 11, an exhaust pipe 96 may be attached in a flexible state to a downstream end 93 of the main passage (a state where relative movement of the exhaust pipe 96 with respect to the downstream end 93 is possible). That is, a flange 94c is formed at a downstream end of a housing 90. A flange 87 is formed on the exhaust pipe 96 also. The flange 94c and the flange 87 are joined by a bolt 89b and a weld nut 89d. A seal ring 89a is disposed between the flange 94c and the flange 87. A spring 89c is disposed in a compressed state between the flange 87 and a head part of the bolt 89b. As a result, the flange 87 is biased toward the flange 94c by the spring 89c, and the seal ring 89a is thereby retained between the flange 87 and the flange 94c. The seal ring 89a is molded from graphite, and has a certain amount of resilience (deformability). As a result, the seal ring 89a deforms when force is exerted between the housing 90 and the exhaust pipe 96, and the exhaust pipe 96 can change relative position with respect to the housing 90 (the downstream end 33 of the main passage). According to this configuration, it is possible to suppress the transmission of vibration to the exhaust pipe 96 from a device (the engine 1) at the upstream side of the exhaust pressure control valve, and vibration of the exhaust pipe 96 and the muffler can thus be prevented.

[0043] Further, in the embodiment described above, the wall face 48 at the downstream side of the outlet port 46 is formed to have a curved surface shape. However, the present invention is not restricted to this configuration. For example, as shown in FIG. 12, a honeycomb 74 may be disposed at an opening part 78 of the outlet port 46. The occurrence of turbulence in the exhaust gas within the outlet port 46 can be prevented by disposing the honeycomb 74 at the opening part 78 of the outlet port 46. Further, as shown in FIG. 13, a cover plate 80 that covers the outlet port 46 may be provided, such that the exhaust gas flow does not collide directly with an opening part 82 of the outlet port 46. Alternatively, as shown in FIGS. 14 and 15, fins 84 may be formed on the wall face 48 at the downstream side of the outlet port 46. Turbulence can be prevented from occurring in the exhaust gas within the outlet port 46 by providing the fins 84.

[0044] Further, in the embodiment described above, the inlet port 16, the outlet port 46 and the bearing portion of the throttle shaft 32 are disposed in the same position in the circumferential direction. However, the present invention is not restricted to this configuration. For example, as shown in FIGS. 16 to 19, an inlet port 116 and a bearing portion of a throttle shaft 132 can be disposed in positions that are not the same in the circumferential direction.

In this case, as shown in FIGS. 16 to 18, it is preferred that the inlet port 116 and the bearing portion of the throttle shaft 132 are disposed so as to overlap in the axial direction of the main passage. The exhaust pressure control valve can be made compact by overlapping the inlet port 116 and the bearing portion of the throttle shaft 132 in the axial direction. Further, as shown in FIG. 19, it is preferred that the inlet port 116 is formed so as to protrude toward the exterior from an inner wall face 112a of a main passage 112. The passage cross-sectional area of the inlet port 116 can be adequately ensured by causing the inlet port 116 to protrude toward the exterior from the main passage 112 (the lower side in FIG. 19) even though the inlet port 116 and the bearing portion of the throttle shaft 132 are overlapping in the axial direction.

(Second Embodiment)

[0045] An exhaust pressure control valve of a second embodiment will be described with reference to figures. The exhaust pressure control valve of the second embodiment has the same configuration as the exhaust pressure control valve of the first embodiment, differing from the first embodiment in the point that a communication hole is formed in the valve member of the main valve. Only the points differing from the first embodiment will be described.

As shown in FIGS. 20 and 21, a valve member 237 of a main valve 230 is oblique with respect to an axis (a central axis) C of a main passage 234 when the valve member 237 is in a state of having closed the main passage 234. Further, a clearance 234d is formed between a circumferential edge of the valve member 237 and an inner wall face of the main passage 234. The clearance 234d is formed along the entire circumference of the valve member 237. It is preferred that the clearance 234d is 0.5 mm or less. This is because the effect of increasing exhaust pressure cannot be achieved adequately when the clearance 234d exceeds 0.5 mm.

Further, a communication hole 237a is formed in the valve member 237 and passes from a front surface to a back surface thereof. The communication hole 237a is formed at a side that becomes a side downstream from a rotation shaft (throttle shaft) 238 when the valve member 237 is in a state of having closed the main passage 234. The communication hole 237a is formed so as to be substantially perpendicular to the surface of the valve member 237.

Furthermore, wire gauze 290 is disposed at the inner wall face of the main passage 234 at a position at a downstream side of the main valve 236. The wire gauze 290 is disposed along the entire circumference of the inner wall face of the main passage 234.

[0046] In a state where the main valve 230 has closed the main passage 234, exhaust gas at an upstream side of the main valve 230 flows out to the downstream side of the main valve 230 from the clearance 234d between the circumferential edge of the valve member 237 and the inner wall face of the main passage 234, and from the communication hole 237a of the valve member 237. At this juncture, the exhaust gas flowing out from the clearance 234d is flowing parallel to the axial direction C of the main passage 234. The exhaust gas flowing out from the communication hole 237a flows toward a center of the main passage 234 (i.e. flows in a direction that is oblique with respect to the axial direction C). As a result, the exhaust gas flowing out from the clearance 234d and the exhaust gas flowing out from the communication hole 237a are mixed efficiently, and the flow speed thereof is thereby reduced.

Further, since the exhaust gas flowing out from the communication hole 237a flows toward the center of the main passage 234, and since the hole diameter of the communication hole 237a is made large because there is only one hole, a large amount of exhaust gas flows out from the communication hole 237a. As a result, the exhaust gas flowing out from the communication hole 237a easily diffuses across the entirety of main passage 234, and the flow speed thereof is thereby reduced.

Moreover, the wire gauze 290 is disposed at the inner wall face of the main passage 234 at the downstream side of the main valve 230. As a result, the flow speed of the exhaust gas flowing out from the clearance 234d is reduced by the wire gauze 290.

The blowing noise when the main passage 234 is closed by the main valve 230 is thereby reduced.

[0047] FIG. 22 shows results of a simulation of the flow state of the exhaust gas when the main valve 230 has been closed in the exhaust pressure control valve of the present embodiment. FIG. 23 shows results of a simulation of the flow state of the exhaust gas when the main valve has been closed in the exhaust pressure control valve in which the valve member of the main valve is not provided with the communication hole.

As is clear from a comparison of FIG. 22 and FIG. 23, in the exhaust pressure control valve of the present embodiment, the exhaust gas is caused to flow into the entirety of the main passage 234 by the exhaust gas flowing out from the communication hole 237a, and it can be understood that the flow speed of exhaust gas flowing out from the clearance 234d can be reduced.

[0048] In the exhaust pressure control valve of the second embodiment, the exhaust gas flowing out from the clearance 234d and the exhaust gas flowing out from the communication hole 237a are mixed efficiently when the main valve 230 is closed, and the flow speed is thereby reduced. Further, the exhaust gas flowing out from the communication hole 237a of the main passage 234 flows toward the center of the main passage 234, and spreads throughout the entirety of the main passage 234. As a result, the flow speed of the exhaust gas flowing from the communication hole 237a is reduced. Further, the flow speed of the exhaust gas flowing out from the clearance 234d is reduced by the wire gauze 290 provided at the inner wall face of the main passage 234. The difference in flow speed between the surrounding exhaust gas and the gas flow out of the clearance 234d and the gas flow out of the communication hole 237a is thereby reduced, and the blowing noise can thereby be reduced.

[0049] In the embodiment described above, one communication hole 237a is formed in the valve member 237. However, the present invention is not restricted to this configuration. For example, a plurality of communication holes can be formed in the valve member. Forming a plurality of communication holes allows the exhaust gas to diffuse across the entirety of the main passage, whereby a reduction in the difference in flow speed can be achieved. Moreover, in the case where a plurality of communication holes are provided, it is preferred that the hole diameter of the communication holes is small. By having the communication holes be small, the flow amount of leakage of the exhaust gas can be suppressed to a constant value while the speed of the exhaust gas flowing out from the communication holes is kept low.

FIG. 24 shows results of a simulation of the flow state of the exhaust gas when a plurality of communication holes are provided in the valve member. As is clear from FIG. 24, the exhaust gas diffuses across the entirety of the main passage and the flow speed can be kept low in the case, also, where a plurality of communication holes are provided in the valve member. Moreover, in the example shown in FIG. 24, downstream end sides of the communication holes are chamfered and a downstream end side of the circumferential edge of the valve member is chamfered. The exhaust gas flowing out from the upstream side of the main valve thereby diffuses easily, thus contributing toward a reduction in the flow speed.

[0050] Several preferred embodiments of the present invention have been described above in detail, however, these embodiments are only examples and do not limit the scope of the claims. Various alternatives and modifications to the above specific examples are included in the technology described in the scope of the patent claims.

Furthermore, the technical elements disclosed in the present specification or figures have technical utility separately or in all types of conjunctions and are not limited to the conjunctions set forth in the claims at the time of filing. Moreover, the art disclosed in the present specification or the drawings achieve a plurality of objects simultaneously, and have technical utility by achieving one of those objects.

Claims

1. An exhaust pressure control valve for controlling the pressure of exhaust gas discharged from an engine, comprising:

a housing that comprises a main passage and a bypass passage,
a main valve that comprises a throttle shaft rotatably supported by the housing and a valve member attached to the throttle shaft, and switches between a closed state in which the valve member closes the main passage, and an open state in which the valve member opens the main passage by rotating the throttle shaft, and
a bypass valve for opening and closing the bypass passage, wherein
an inlet port that connects to an upstream end of the bypass passage is provided in an inner wall face of the main passage at an upstream side of the main valve,
an outlet port that connects to a downstream end of the bypass passage is provided in the inner wall face of the main passage at a downstream side of the main valve, and
when the main valve is in the closed state, a position of the outlet port is offset in the circumferential direction from a position of a point on a circumferential edge of the valve member at which the distance from an axis of the throttle shaft to the circumferential edge of the valve member is longest.

2. The exhaust pressure control valve according to claim 1, wherein the position of the outlet port in the circumferential direction is substantially identical to the position of a supporting part in the circumferential direction that is provided for supporting the throttle shaft within the main passage.

3. The exhaust pressure control valve according to claim 1 or 2, further comprising:

a bearing disposed in a through hole formed in the housing and supporting one end of the throttle shaft, an actuator that is connected to the other end of the throttle shaft that protrudes toward the exterior of the housing from the through hole and that drives the rotation of the throttle shaft, and a seal member that seals between the throttle shaft and an inner wall face of the through hole.

4. The exhaust pressure control valve according to any one of claims 1 to 3, wherein a flow characteristic changing means that changes the flow characteristics of the exhaust gas is provided in the outlet port.

5. The exhaust pressure control valve according to claim 4, wherein the flow characteristic changing means is a wall face having a curved surface shape and formed at a downstream side of the outlet port.

6. The exhaust pressure control valve according to claim 4, wherein the flow characteristic changing means is a flow rectifying member that is attached to a wall face at a downstream side of the outlet port and that rectifies the flow of exhaust gas.

7. The exhaust pressure control valve according to any one of claims 1 to 6, wherein
a space is formed, when the main valve is in the closed state, along the entire circumference of the circumferential edge of the valve member, between the circumferential edge of the valve member and the inner wall face of the main passage, and
a communication hole that passes from a front surface to a back surface is formed in the valve member, such that when the main valve is in the closed state, the flow direction of exhaust gas flowing out from the communication hole is oblique with respect to the axial direction of the main passage.

8. The exhaust pressure control valve according to claim 7, wherein
when the main valve is in the closed state, a surface of the valve member is oblique with respect to the axial direction of the main passage, and the communication hole is formed in a position in the surface of the valve member at a downstream side from the throttle shaft and is formed in a direction substantially perpendicular to the surface of the valve member.

9. The exhaust pressure control valve according to any one of claims 1 to 8, further comprising:

a gas flow speed reducing means that reduces the flow speed of the exhaust gas near the inner wall face, provided at the inner wall face of the main passage at a downstream side from the main valve.

10. The exhaust pressure control valve according to claim 9, wherein the gas flow speed reducing means is wire gauze.

11. An exhaust pressure control valve for controlling the pressure of exhaust gas discharged from an engine, comprising:

a housing that comprises a main passage and a bypass passage,
a main valve that comprises a throttle shaft rotatably supported by the housing and a valve member attached to the throttle shaft, and switches between a closed state in which the valve member closes the main passage and an open state in which the valve member opens the main passage by rotating the throttle shaft, and
a bypass valve for opening and closing the bypass passage, wherein
an inlet port that connects to an upstream end of the bypass passage is provided in an inner wall face of the main passage at an upstream side of the main valve,
an outlet port that connects to a downstream end of the bypass passage is provided in the inner wall face of the main passage at a downstream side of the main valve, and
a flow characteristic changing means that changes the flow characteristics of the exhaust gas is provided on the outlet port.

12. An exhaust pressure control valve for controlling the pressure of exhaust gas discharged from an engine, comprising:

a housing that comprises an exhaust passage, and
a valve that comprises a rotation shaft rotatably supported by the housing and a valve member attached to the rotation shaft, and switches between a closed state in which the valve member closes the exhaust passage and an open state in which the valve member opens the exhaust passage by rotating the rotation shaft, wherein
a communication hole that passes from a front surface to a back surface is formed in the valve member such that when the valve is in the closed state, the flow direction of exhaust gas flowing out from the communication hole is oblique with respect to the axial direction of the exhaust passage.

13. An exhaust pressure control valve for controlling the pressure of exhaust gas discharged from an engine, comprising:

a housing that comprises an exhaust passage, and
a valve that comprises a rotation shaft rotatably supported by the housing and a valve member attached to the rotation shaft, and switches between a closed state in which the valve member closes the exhaust passage and an open state in which the valve member opens the exhaust passage by rotating the rotation shaft, and
a gas flow speed reducing means that is provided at an inner wall face of the exhaust passage at a downstream side from the valve, wherein the gas flow speed reducing means reduces the flow speed of the exhaust gas near the inner wall face.

14. An exhaust pressure control valve for controlling the pressure of exhaust gas discharged from an engine, comprising:

a housing having a main passage and a bypass passage,
a main valve for opening and closing the main passage,
a first valve opening and closing device for driving the opening and closing of the main valve,
a bypass valve for opening and closing the bypass passage, and
a second valve opening and closing device for driving the opening and closing of the bypass valve, wherein
the first valve opening and closing device is set such that the time for the main valve to change from a closed state to an open state is longer than the time for the main valve to change from the open state to the closed state.

15. The exhaust pressure control valve according to claim 14, wherein
the first valve opening and closing device comprises:

a diaphragm type actuator for driving the opening and closing of the main valve,
a discharging and feeding means for discharging gas from and feeding gas to a pressure chamber of the actuator,
a pipe connecting the exhausting and feeding means and the pressure chamber of the actuator, and
a flow amount regulating means that is disposed on the pipe and switches between a first state

in which the cross-sectional area of a through opening through which gas passes is large and a second state in which the cross-sectional area of the through opening through which gas passes is small, wherein
the actuator is set so as to close the main valve when the pressure of gas within the pressure chamber exceeds a predetermined pressure, and so as to open the main valve when the pressure of the gas within the pressure chamber is equal to or below the predetermined pressure, and
the flow amount regulating means is put in the first state when gas is to be discharged from the pressure chamber, and is put in the second state when gas is to be supplied to the pressure chamber.

16. The exhaust pressure control valve according to claim 14 or 15, wherein
the second valve opening and closing device comprises a movable member that moves linearly in accordance with the pressure of exhaust gas at an upstream side of the main valve, and a link mechanism that converts the linear movement of the movable member into opening and closing movement of the bypass valve.

17. The exhaust pressure control valve according to claim 16, wherein
the second valve opening and closing device comprises a housing chamber for housing the movable member, an inlet pipe for leading the exhaust gas from the upstream side of the main valve into one of housing chambers divided by the movable member, and a biasing means that biases the movable member toward the one housing chamber and is disposed in the other of the housing chambers.

18. The exhaust pressure control valve according to claim 16 or claim 17, wherein a connecting hole to which a DPF device can be connected is formed at an upstream end of the housing.

19. The exhaust pressure control valve according to any one of claims 14 to 18, further comprising:

a flange part provided at a downstream end of the housing and attached to an exhaust pipe, wherein the flange part and the exhaust pipe joins flexibly.

20. An exhaust pressure control valve for controlling the pressure of exhaust gas discharged from an engine, comprising:

a housing having a main passage and a bypass passage,
a main valve for opening and closing the main passage,
a first valve opening and closing device for driving the opening and closing of the main valve,
a bypass valve for opening and closing the bypass passage, and
a second valve opening and closing device for driving the opening and closing of the bypass valve, wherein
the bypass valve is disposed at a central part of the bypass passage at a position apart from the main passage, and
the second valve opening and closing device comprises a movable member that moves linearly in accordance with the pressure of exhaust gas at an upstream side of the main valve, and a link mechanism that converts the linear movement of the movable member into opening and closing movement of the bypass valve.

FIG. 1

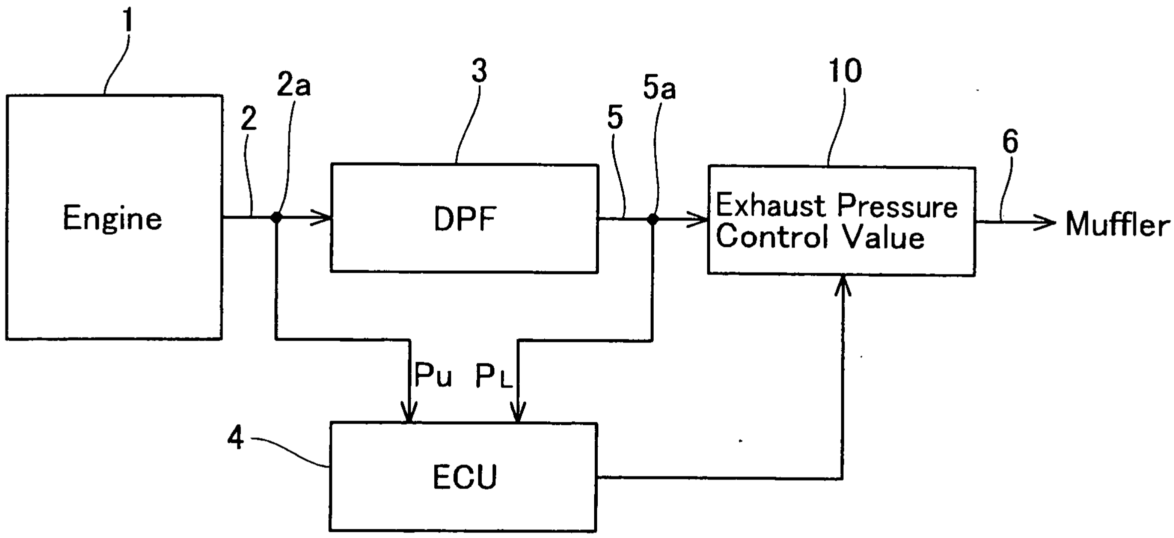

1
2
2a
3
5
5a
10
6
Engine
DPF
Exhaust Pressure
Control Value
Muffler
Pu
PL
4
ECU

FIG. 2

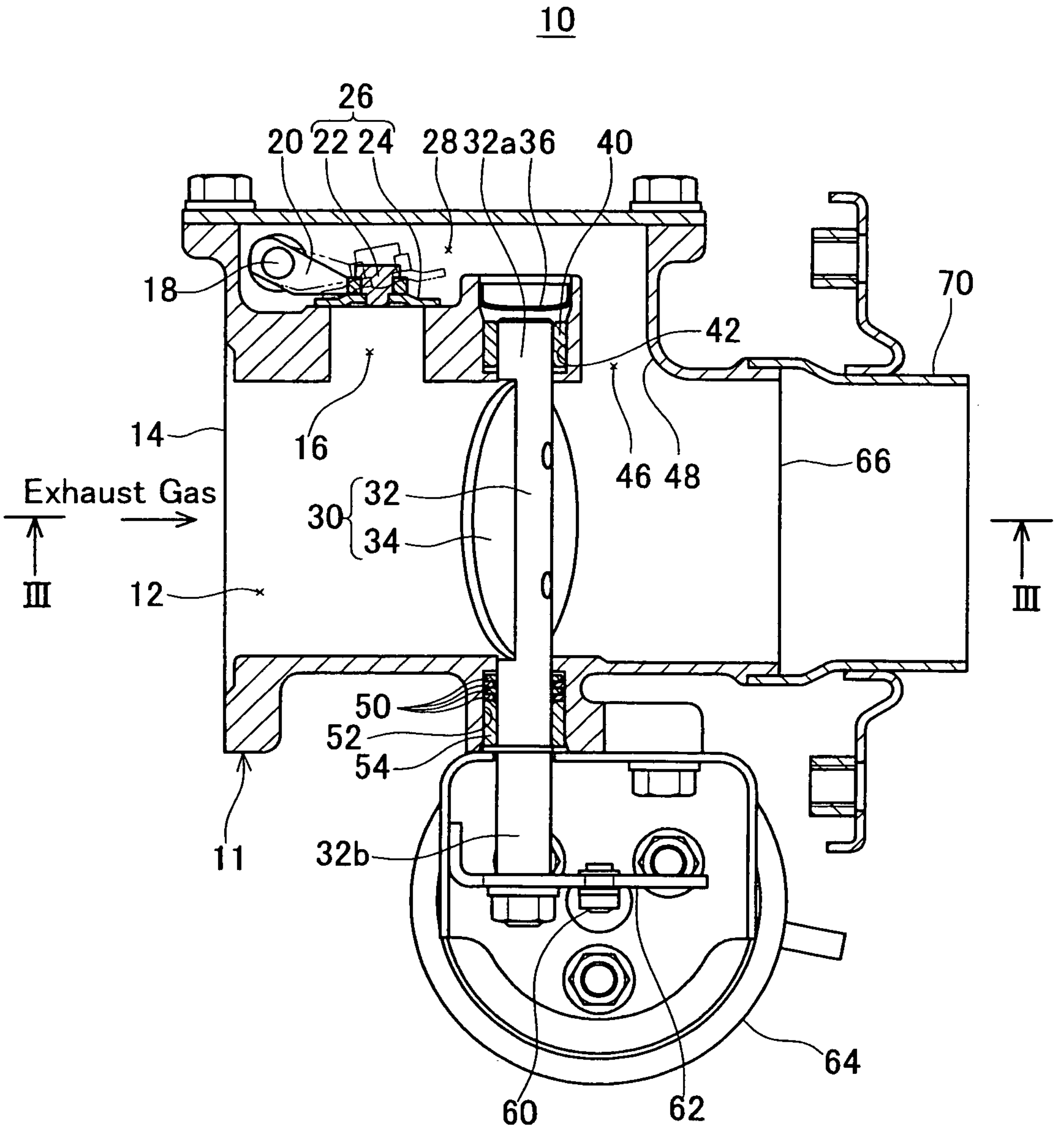

10
26
20
22
24
28
32a
36
40
18
70
42
14
16
46
48
66
Exhaust Gas
30
32
34
III
12
III
50
52
54
11
32b
64
60
62

FIG. 3

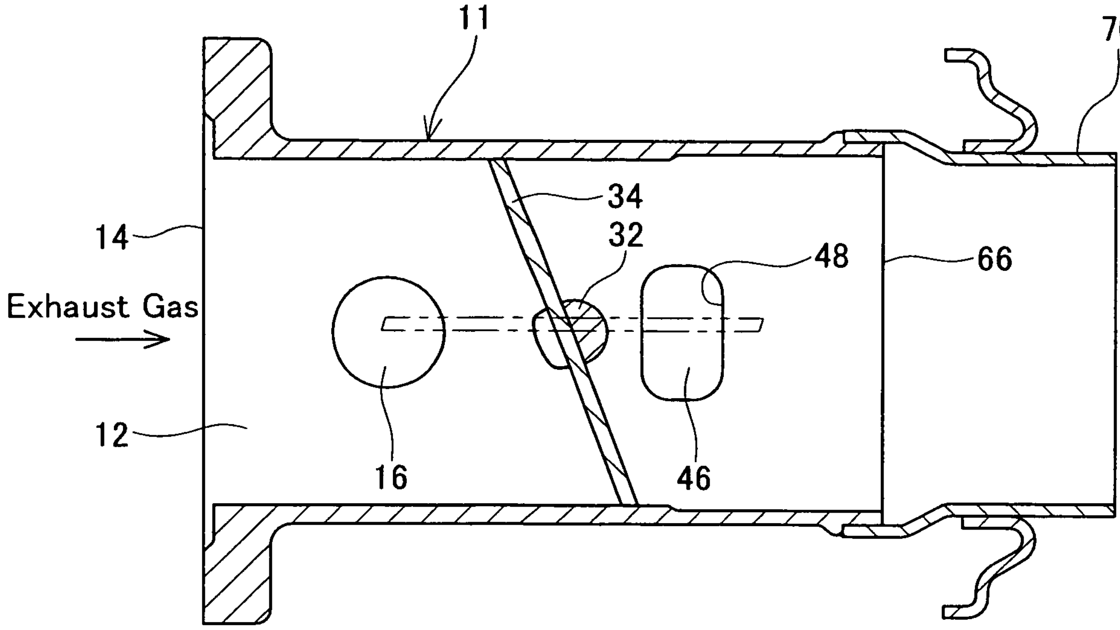


FIG. 4

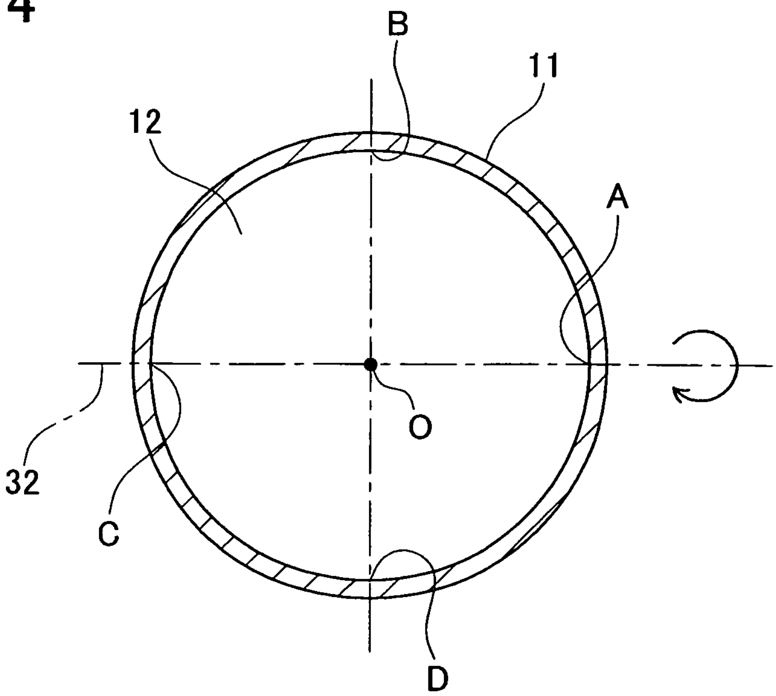


FIG. 5

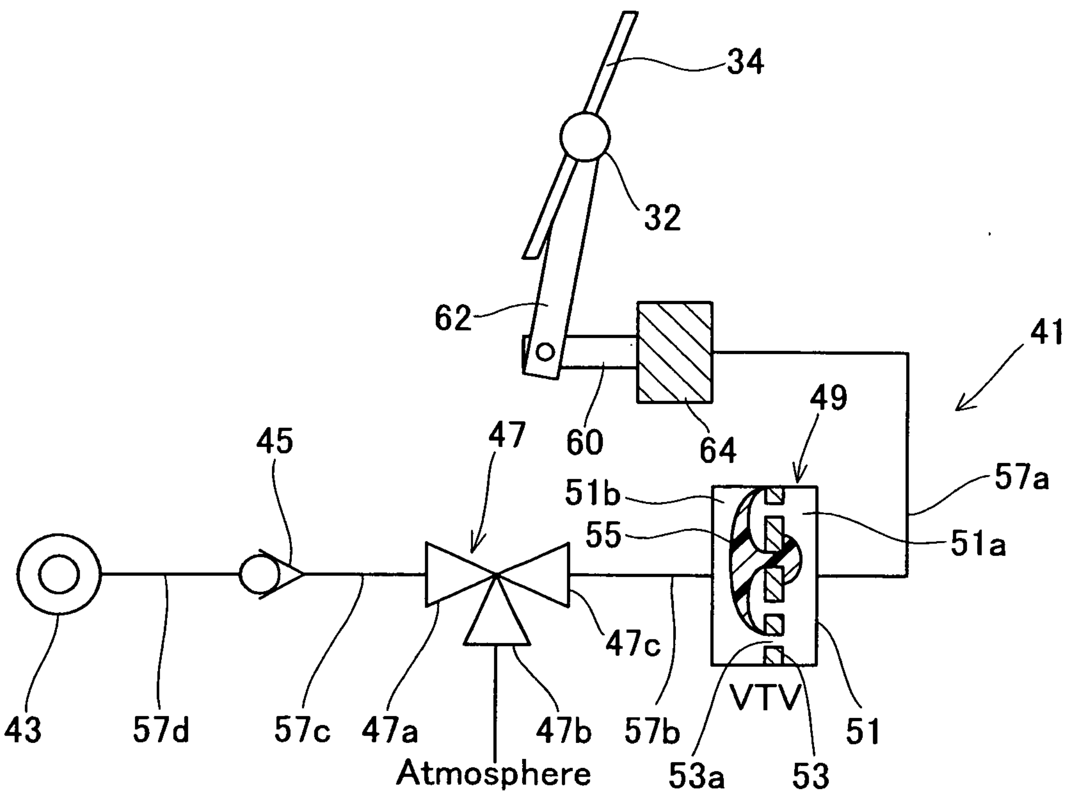

34
32
62
41
49
60
64
45
47
57a
51b
55
51a
47c
VTV
43
57d
57c
47a
47b
57b
51
Atmosphere
53a
53

FIG. 6

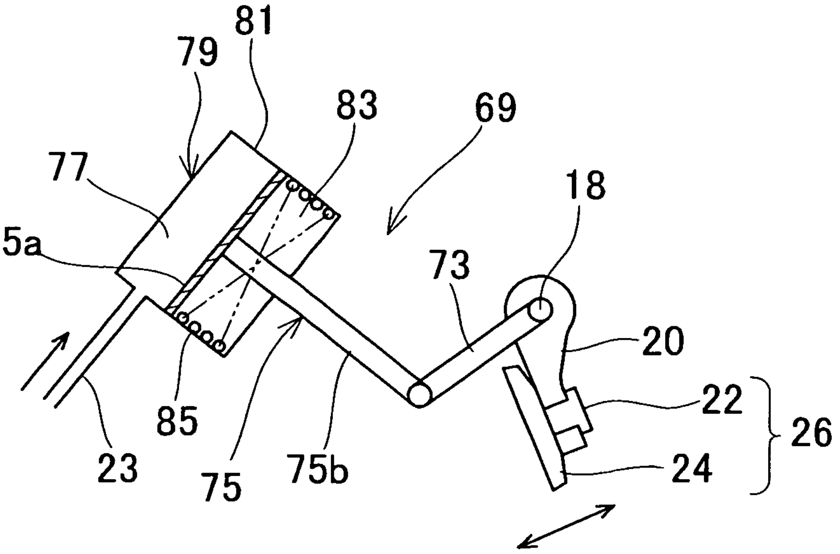


FIG. 7

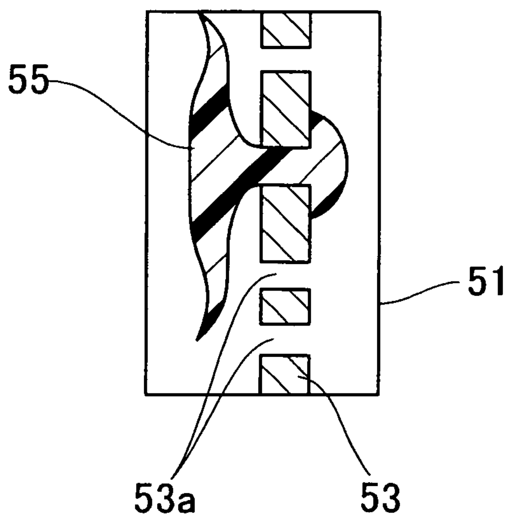


FIG. 8

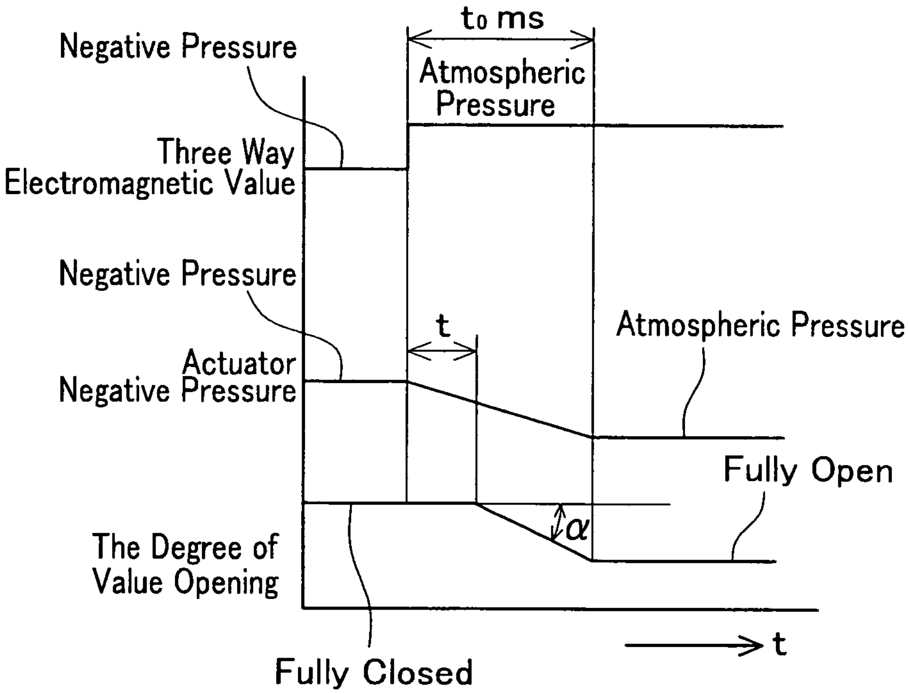

t0 ms
Negative Pressure
Atmospheric Pressure
Three Way Electromagnetic Value
Negative Pressure
t
Atmospheric Pressure
Actuator Negative Pressure
Fully Open
α
The Degree of Value Opening
t
Fully Closed

FIG. 9

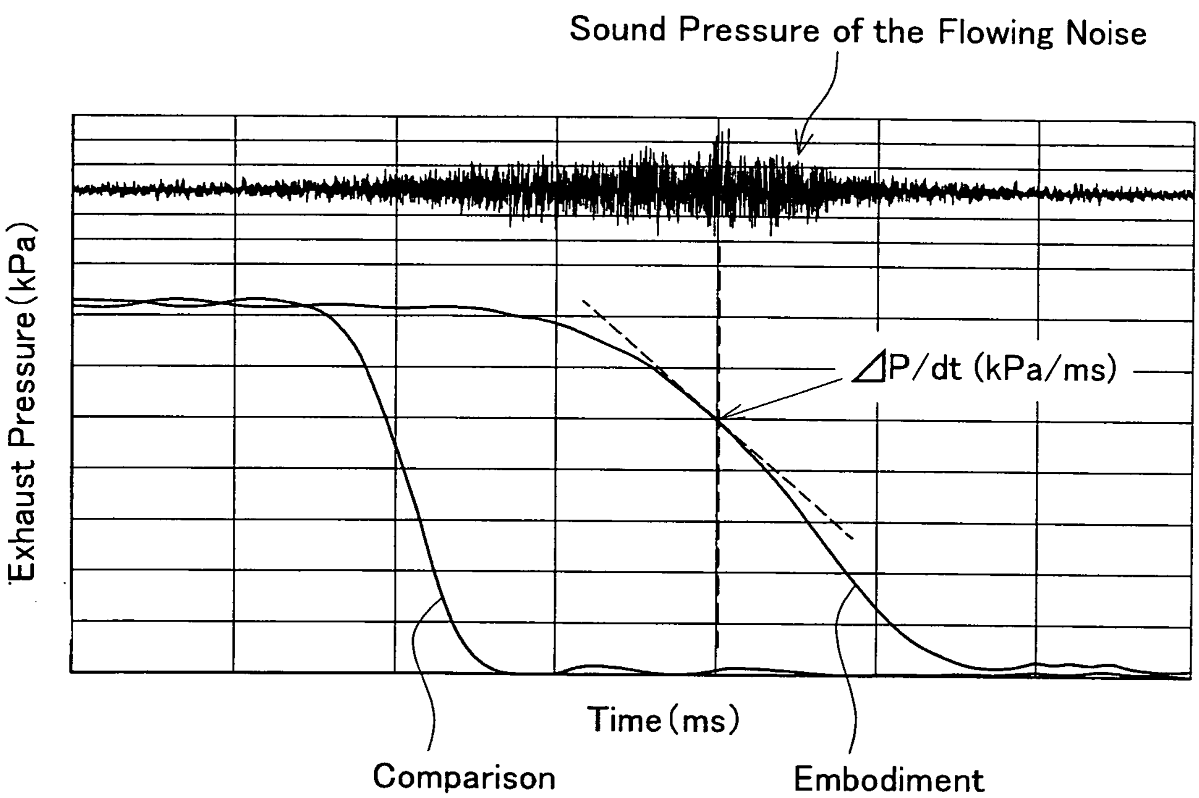

Sound Pressure of the Flowing Noise
Exhaust Pressure (kPa)
⊿P/dt (kPa/ms)
Time (ms)
Comparison
Embodiment

FIG. 10

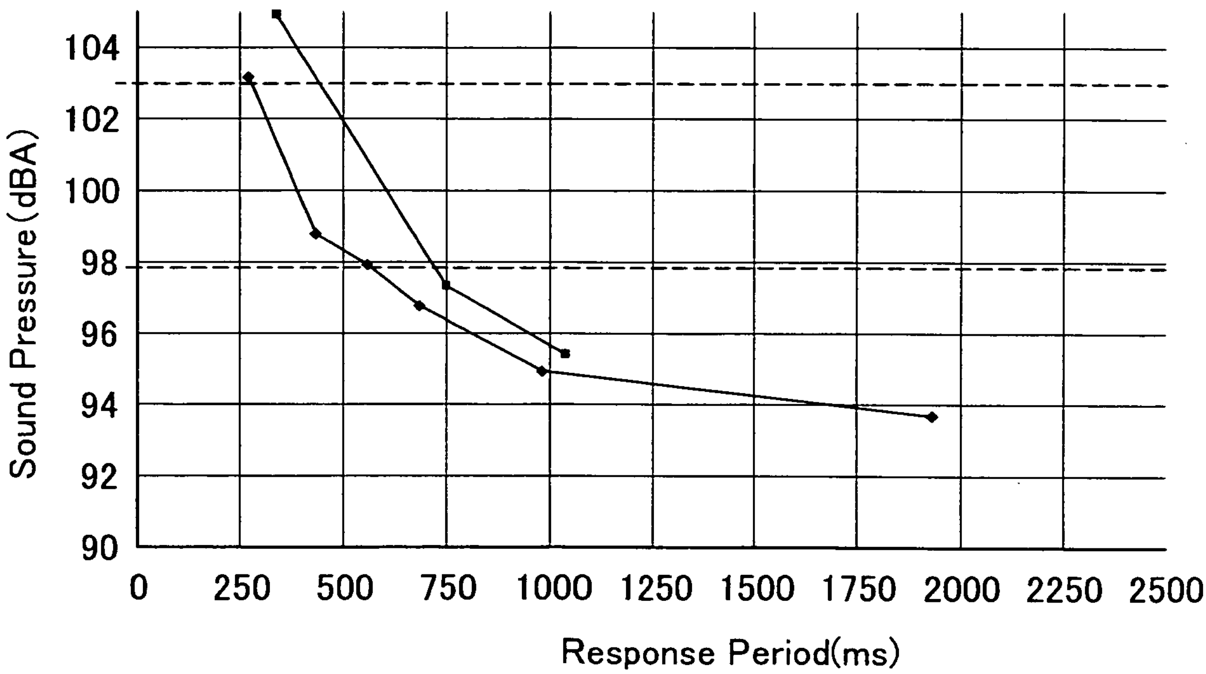

104
102
100
98
96
94
92
90
Sound Pressure (dBA)
0
250
500
750
1000
1250
1500
1750
2000
2250
2500
Response Period(ms)

FIG. 11

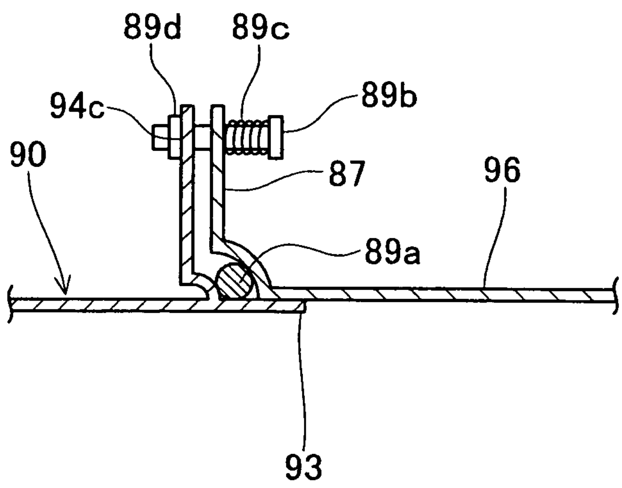


FIG. 12

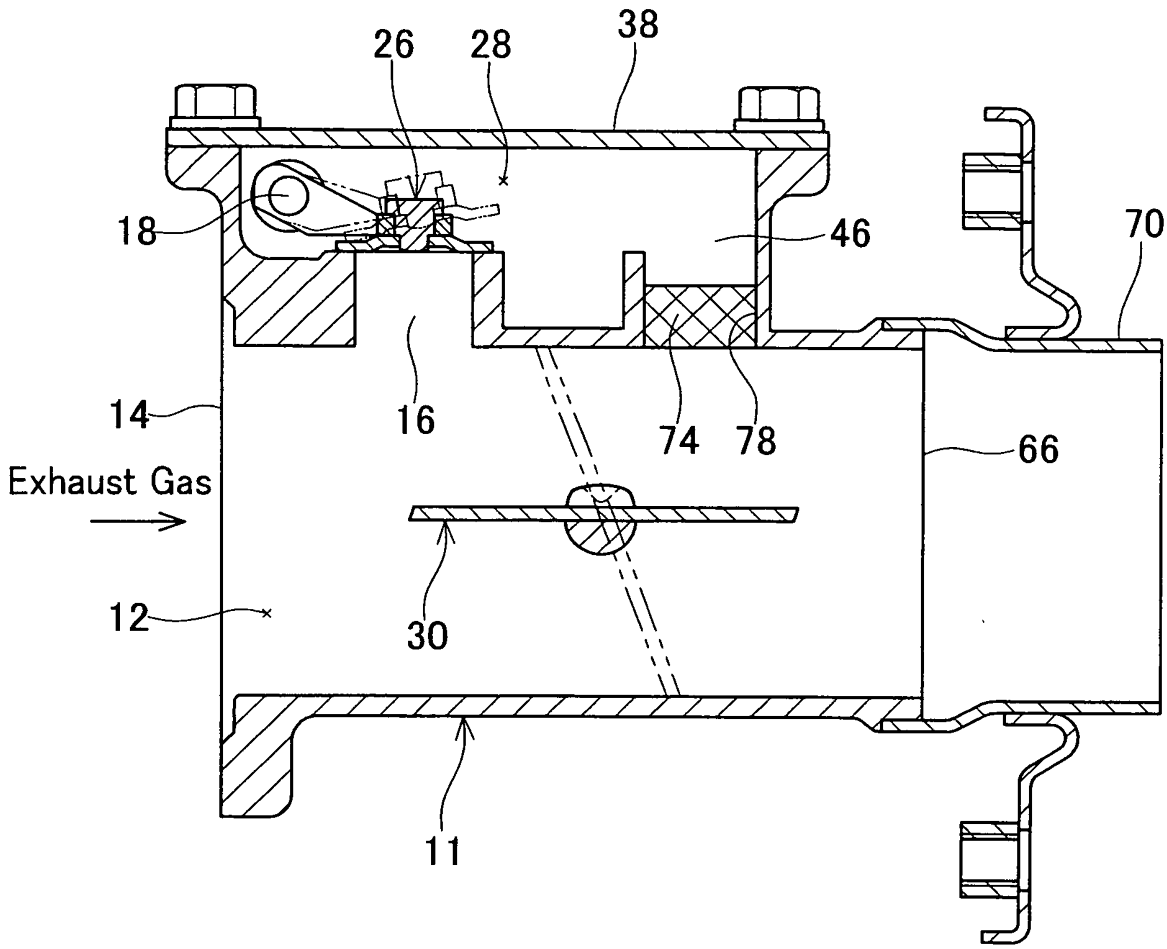


FIG. 13

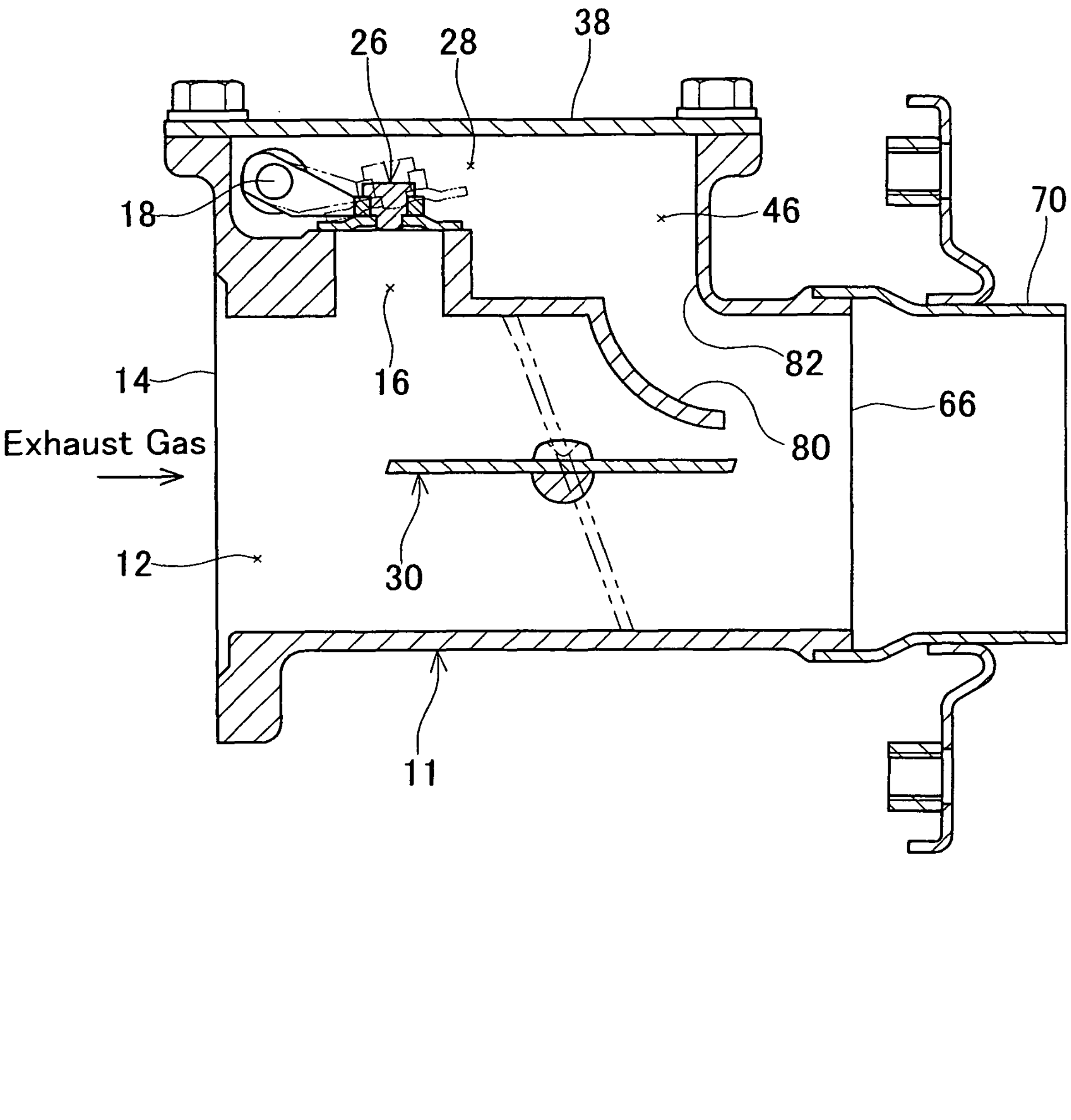


FIG. 14

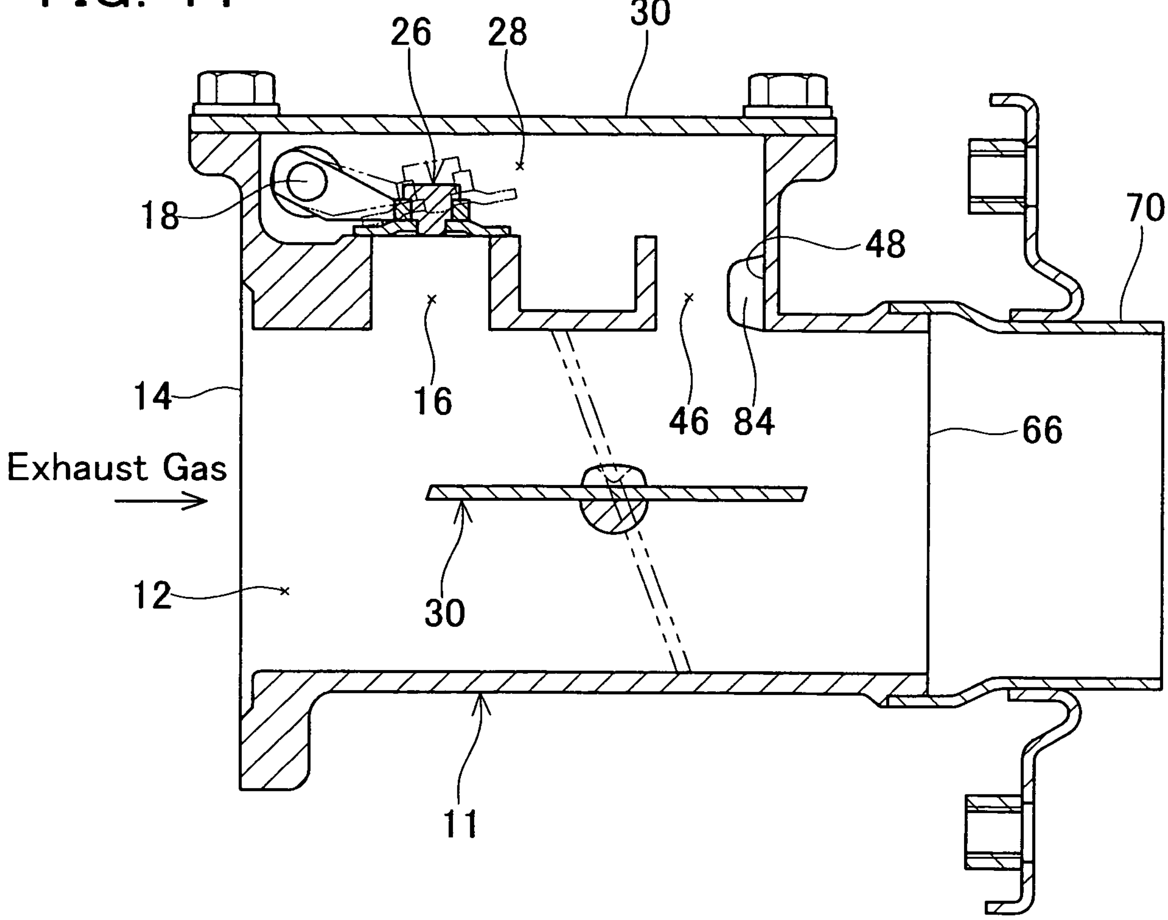


FIG. 15

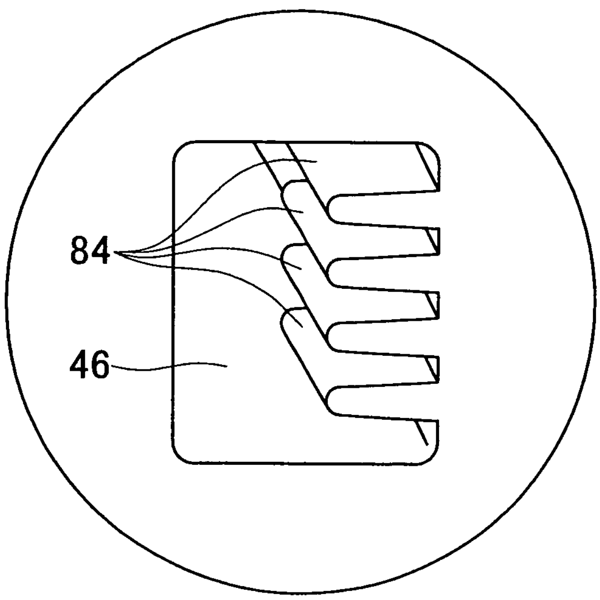


FIG. 16

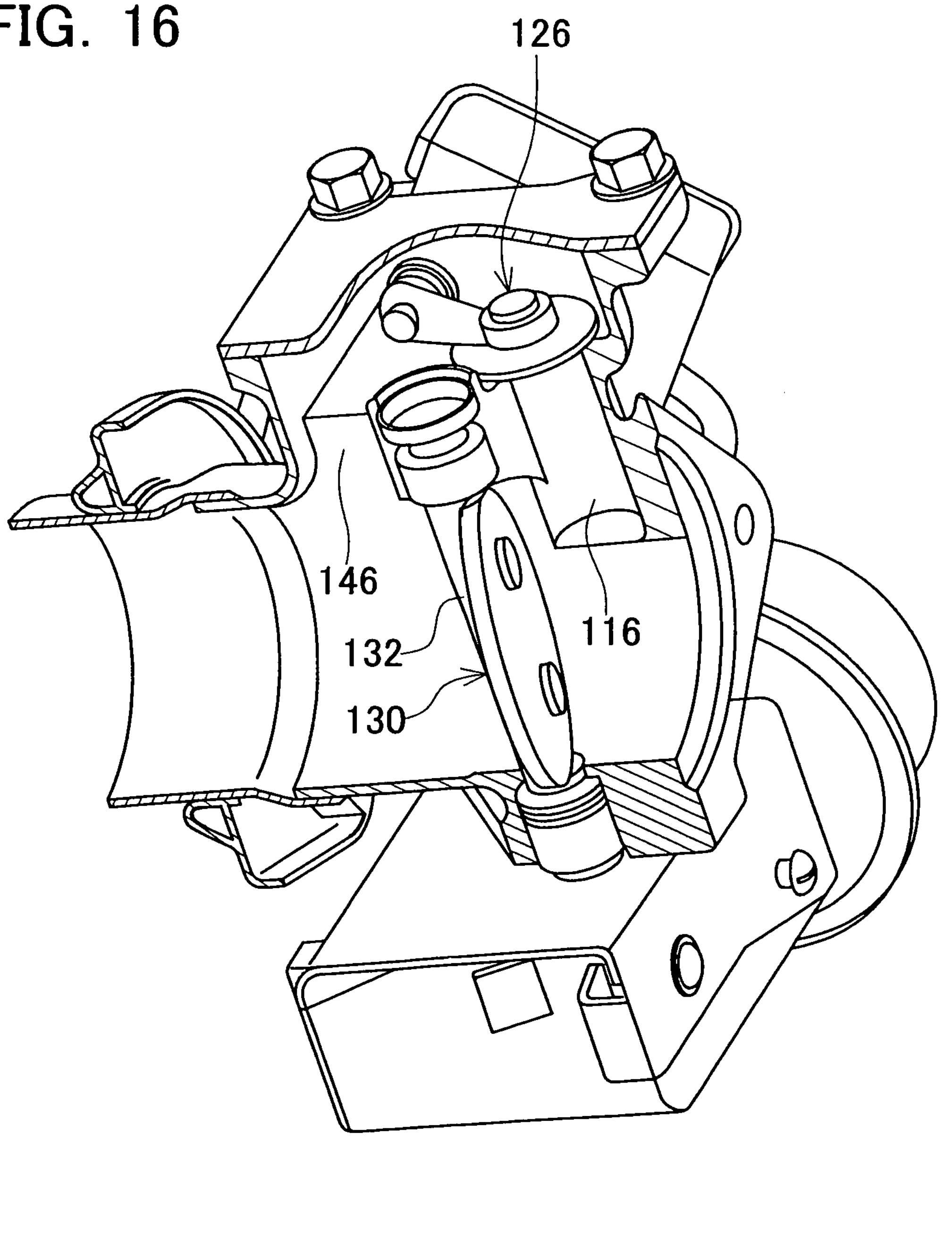


FIG. 17

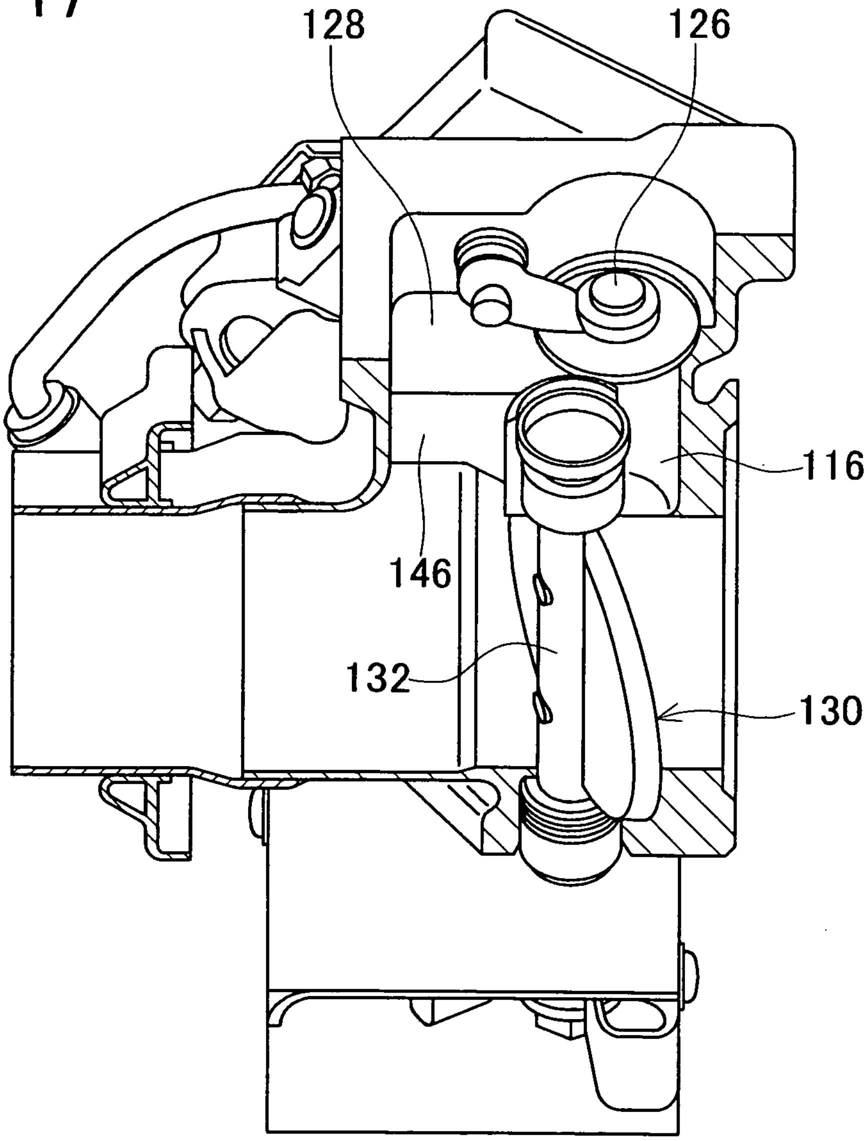


FIG. 18

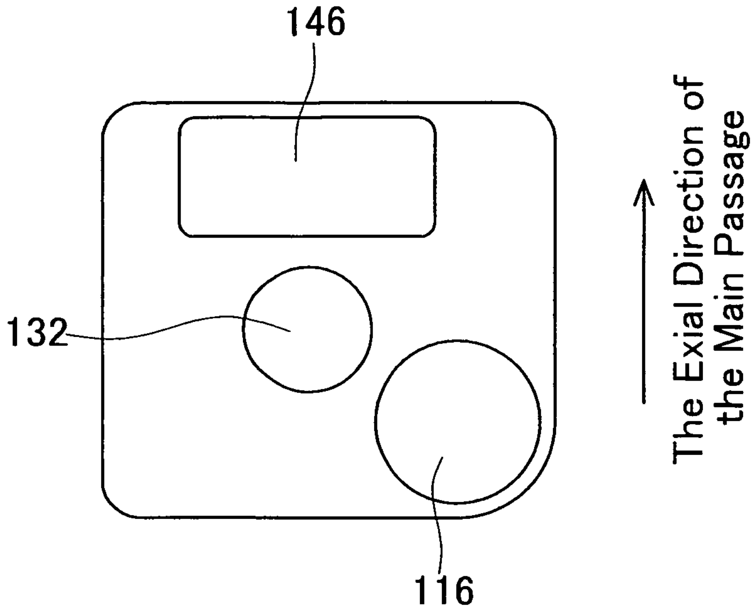

146
132
116
The Exial Direction of
the Main Passage

FIG. 19

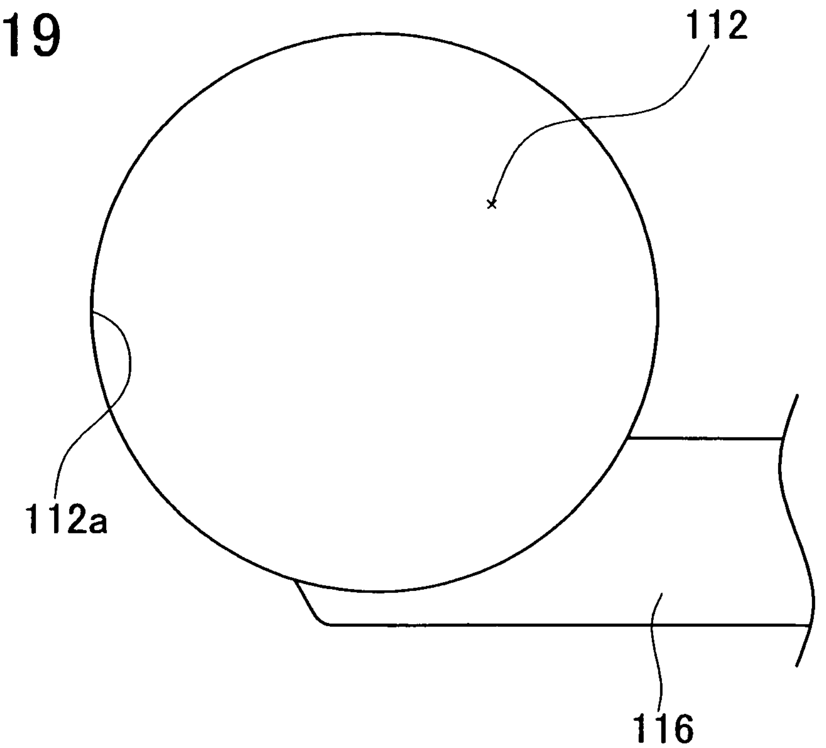

112
112a
116

FIG. 20

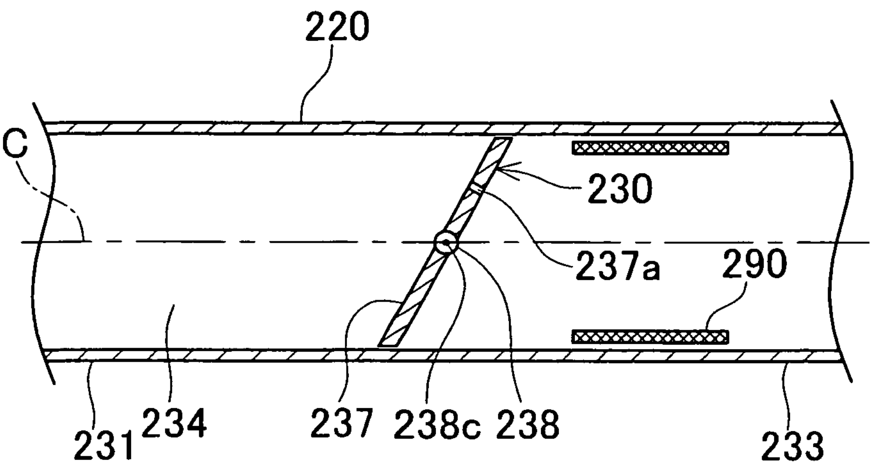


FIG. 21

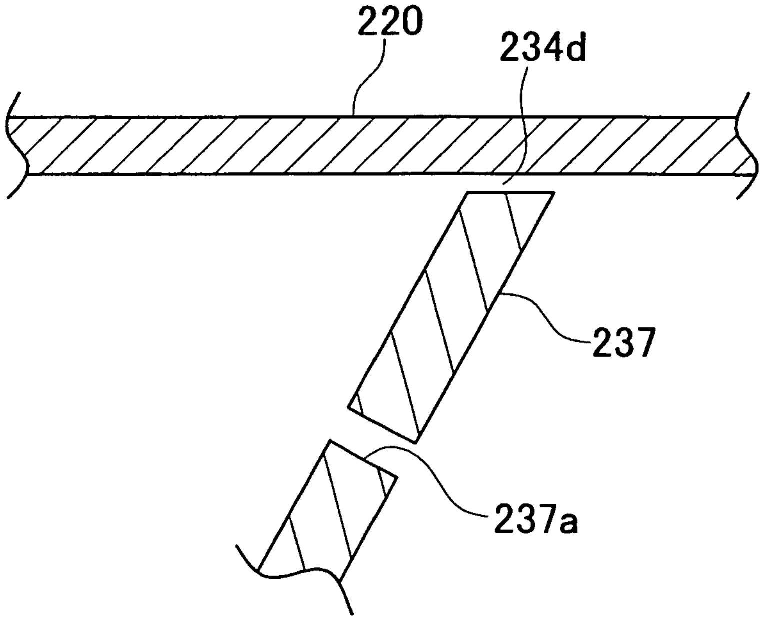


FIG. 22

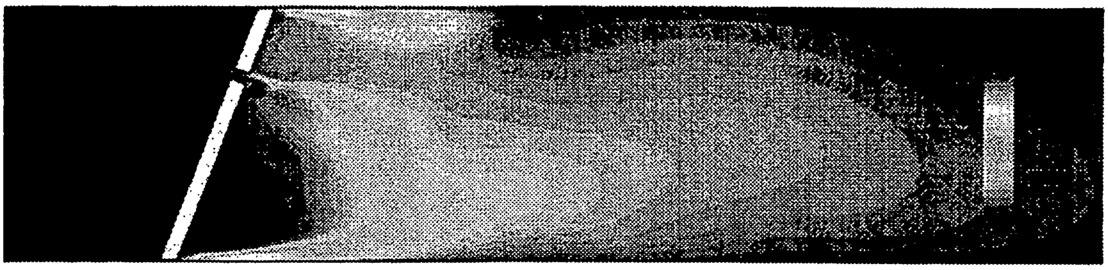


FIG. 23

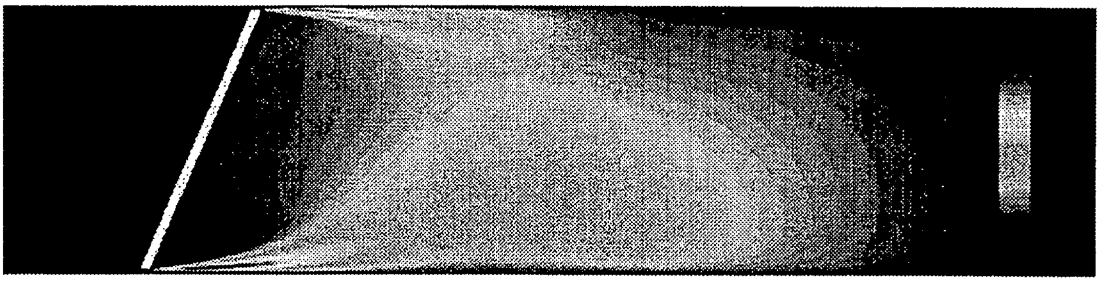
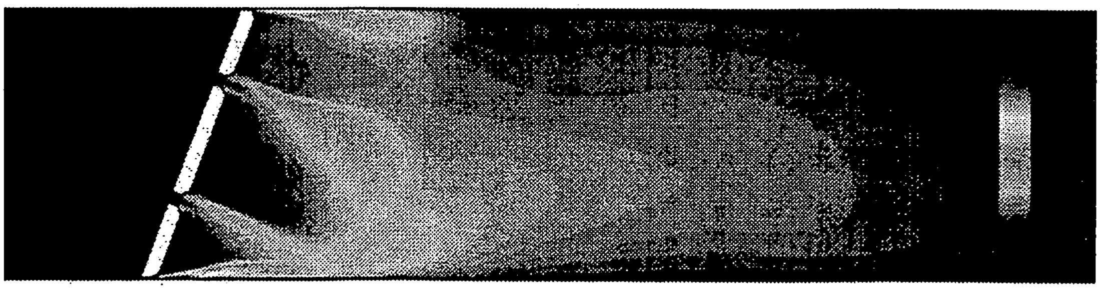


FIG. 24



REFERENCES CITED IN THE DESCRIPTION

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