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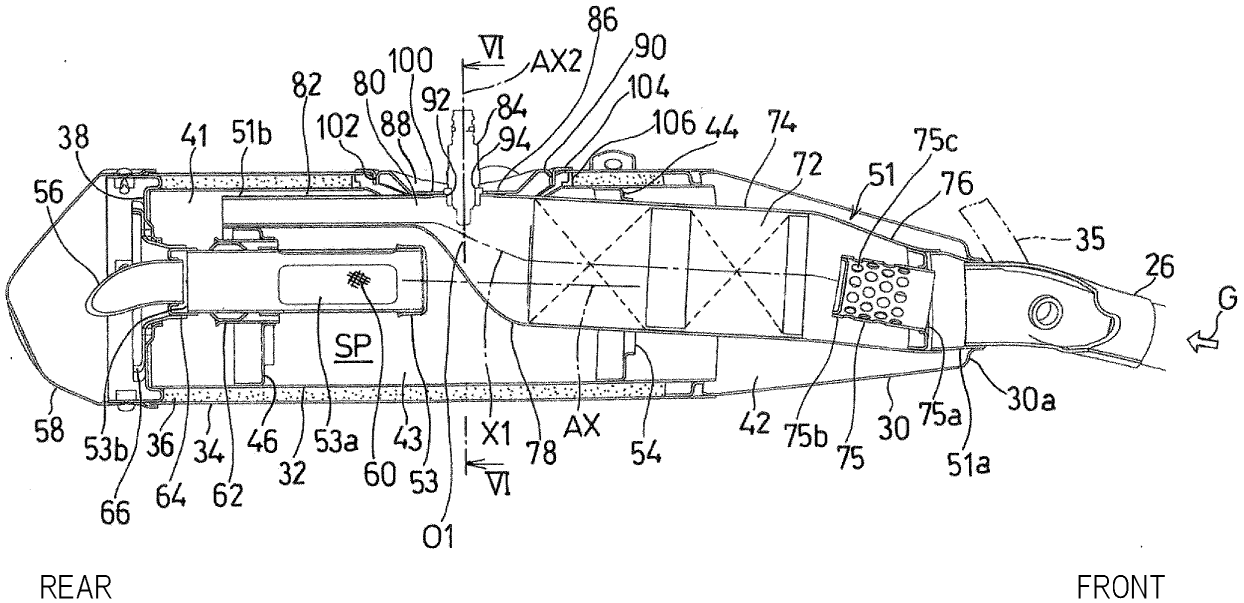
(54) **VEHICLE EXHAUST MUFFLER**

(57) A vehicle exhaust muffler 20 includes an inner tube 32 in which a silencer chamber SP is defined, an outer tube 34 forming the outer shell of the muffler 20, a pipe member 51 which is disposed in the silencer chamber SP and through which exhaust gas G is allowed to pass, a sensor 84 which detects a state of the exhaust gas G flowing through the pipe member 51, and a closure 88 disposed around the sensor 84 to block gases inside the silencer chamber SP from escaping into the external environment. The closure 88 includes a pipe-side connection 100 at which the closure 88 is coupled to the pipe member 51 and an outer tube-side connection 102 at which the closure 88 is coupled to the outer tube 34.

Fig. 4



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Description

BACKGROUND OF THE INVENTION

(Field of the Invention)

[0001] The present disclosure relates to a vehicle exhaust muffler, which includes a sensor mounted thereto for exhaust gas sensing.

(Description of Related Art)

[0002] Some motorcycles are provided with a catalytic converter in an exhaust gas passage to purify exhaust gas (e.g., JP Laid-open Patent Publication No. 2017-110616). JP Laid-open Patent Publication No. 2017-110616 discloses a motorcycle with exhaust gas sensors that are located upstream and downstream of a catalytic converter, respectively.

[0003] In the case that the exhaust muffler comprises an inner tube in which a silencer chamber is defined and an outer tube which forms the outer shell of the muffler, the mounting of an exhaust gas sensor on such an exhaust muffler can be difficult because assembly errors could occur between the inner and outer tubes.

SUMMARY OF THE INVENTION

[0004] The present disclosure provides a vehicle exhaust muffler, to which muffler an exhaust gas sensor can be mounted with minimal influences from possible assembly errors.

[0005] The present disclosure provides a vehicle exhaust muffler which includes: an inner tube in which a silencer chamber is defined; an outer tube forming the outer shell of the muffler; a pipe member which is disposed in the silencer chamber and through which exhaust gas is allowed to pass; a sensor configured to detect a state of the exhaust gas flowing through the pipe member; and a closure disposed around the sensor to block gases inside the silencer chamber from escaping into the external environment. The closure includes a pipe-side connection at which the closure is coupled to the pipe member and an outer tube-side connection at which the closure is coupled to the outer tube. The sensor may detect, for example, the temperature, the flow velocity, or a component of the exhaust gas, and can be an oxygen sensor which detects the content of oxygen in the exhaust gas, by way of example.

[0006] The closure in a vehicle exhaust muffler according to the present disclosure is not coupled to the inner tube, but is coupled to the pipe member and the outer tube. Therefore, the exhaust gas sensor can be allowed to be mounted to the muffler with little influence from the possible assembly errors between the inner tube and the outer tube of the muffler. Further, since the closure is designed to couple the pipe member and the outer tube, the inner tube, which has a larger size than the pipe member, does not need to have a feature to allow a component to be coupled to the closure, thereby allowing the structure of the inner tube to be simplified.

[0007] Any combinations of at least two features disclosed in the claims and/or the specification and/or the drawings should also be construed as encompassed by the present disclosure. Especially, any combinations of two or more of the claims should also be construed as encompassed by the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The present disclosure will be more clearly understood from the following description of preferred embodiments made with reference to the accompanying drawings. However, the embodiments and the drawings are given merely for the purpose of illustration and explanation, and should not be used to delimit the scope of the present disclosure, which scope is to be delimited by the appended claims. In the accompanying drawings, alike numerals are assigned to and indicate alike parts throughout the different figures:

Fig. 1 is a side view of one type of a vehicle in the form of a motorcycle with an exhaust muffler, in accordance with a first embodiment of the present disclosure;
Fig. 2 is a side view of the exhaust muffler;
Fig. 3 is a side view of the exhaust muffler of Fig. 2 without a muffler cover;
Fig. 4 is a vertical cross-sectional view of the exhaust muffler;
Fig. 5 is a horizontal cross-sectional view of the exhaust muffler;
Fig. 6 is a cross-sectional view of the exhaust muffler taken along the line VI-VI in Fig. 4; and
Fig. 7 is a cross-sectional view of a mounting structure for a downstream sensor of the exhaust muffler.

DESCRIPTION OF EMBODIMENTS

[0009] What follows is a description of preferred embodiments of the present disclosure made with reference to the drawings. In the following discussions, the terms "front" and "forward(s)" and the terms "rear" and "rearward(s)" refer to sides facing "the front" and "the rear" of a vehicle, respectively, as seen along the direction of travel of the vehicle. Accordingly, a front-to-rear or rear-to-front direction for the vehicle coincides with the longitudinal direction of the vehicle. The terms "left" and "leftward(s)" and the terms "right" and "rightward(s)" refer to sides facing "the left" and "the right" of the vehicle, respectively, as viewed from a driver seated in the vehicle. Accordingly, a left-to-right or right-to-left direction for the vehicle coincides with the widthwise direction of the vehicle.

[0010] Fig. 1 is a side view of one type of a vehicle in the form of a motorcycle with an exhaust muffler, in accordance with a first embodiment of the present disclosure.

The motorcycle in Fig. 1 is a motorcycle designed for off-road uses. However, a motorcycle designed for off-road uses is only one of the non-limiting examples of the vehicle. Moreover, an exhaust muffler according to the present disclosure can also be applied to straddled vehicles different from motorcycles, such as, for example, three-wheeled vehicles, four-wheeled buggies, and small planing crafts.

[0011] The vehicle body frame structure FR of the motorcycle includes a main frame 1 that forms the front half of the structure FR and a rear frame 2 that forms the rear half of the structure FR. The main frame 1 extends diagonally downwards from a front-end head pipe 4 towards the rear. The main frame 1 is curved downwards at the rear end 1a thereof and extends substantially vertically downwards therefrom.

[0012] The rear frame 2 includes an upper rear frame piece 2a and a lower rear frame piece 2b. The upper rear frame piece 2a has a front end that is coupled to a portion of the main frame 1, which portion is located forwards of and above the rear end 1a of the main frame 1a, and extends rearwards from the main frame 1. The lower rear frame piece 2b has a front end that is coupled to a portion of the main frame 1, which portion is located slightly below the rear end 1a of the main frame 1. The lower rear frame piece 2b extends diagonally upwards from the main frame 1 towards the rear and has a rear end that is coupled to a rear portion of the upper rear frame piece 2a.

[0013] A front fork 8 is rotatably supported by the head pipe 4 through a steering shaft (not shown). The front fork 8 has an upper end to which a steering handle 7 is secured. The front fork 8 has a lower end to which a front wheel 10 is mounted.

[0014] A swingarm bracket 9 is provided at a portion of the main frame 1 which is located below the rear end 1a of the main frame 1. A swingarm 12 is supported on a pivot shaft 11 that is attached to the swingarm bracket 9, so as to freely swing up and down about the pivot shaft 11. The swingarm 12 has a rear end on which a rear wheel 14 is supported.

[0015] An engine E which serves as a drive source for the motorcycle is located forwards of and below the main frame 1 and attached to the main frame 1. The engine E drives the rear wheel 14 through power transmission components (not shown) such as a drive chain. A single-cylinder four-cycle engine in the instant embodiment is only one of the non-limiting examples of the engine E.

[0016] The engine E is formed with an intake port 16 on the rear side thereof and with an exhaust port 18 on the front side thereof. The air introduced via the intake port 16 is mixed with a fuel to produce an air-fuel mixture and burned in a combustion chamber. The resultant is discharged via the exhaust port 18. An air intake device ID connects to the intake port 16. The air intake device ID is where the air taken in from the external environment is mixed with the fuel to produce the air-fuel mixture and from where the air-fuel mixture is delivered to the intake port 16 of the engine E as intake air.

[0017] The exhaust port 18 connects to an exhaust pipe 22. The exhaust pipe 22 extends on the right side of the engine E towards the rear and connects to an exhaust muffler 20 which is located rightwards of and above the rear wheel 14. A part of the exhaust muffler 20 - in particular, the upper half thereof - is externally covered by a muffler cover 24. The muffler cover 24 is positioned over the exhaust muffler 20 with a radial gap thereto. By covering the exhaust muffler 20 with the muffler cover 24, a driver in a seated position is protected against direct contact with the exhaust muffler 20. The muffler cover 24 is produced, for example, from a metal sheet and detachably attached to the exhaust muffler 20. However, the above is only one of non-limiting examples of the arrangement of the exhaust pipe 22 and the exhaust muffler 20. The exhaust muffler 20 will be later described in detail.

[0018] The main frame 1 supports a fuel tank 25. The fuel tank 25 stores the fuel for the engine E. The fuel tank 25 is located above the engine E. A seat 26 on which the driver can be seated is located rearwards of the fuel tank 25 and is supported on the upper rear frame piece 2a.

[Exhaust Muffler]

[0019] An exhaust muffler 20 according to the present disclosure will be discussed below. Fig. 2 is a side view of the exhaust muffler 20. Fig. 3 is a side view of the exhaust muffler 20 of without the muffler cover 24. Fig. 4 is a vertical cross-sectional view of the exhaust muffler 20. Fig. 5 is a horizontal cross-sectional view of the exhaust muffler 20. Fig. 6 is a cross-sectional view of the exhaust muffler 20 taken along the line VI-VI in Fig. 4. In the following discussions, the terms "upstream" and "downstream" refer to an upstream side and a downstream side, respectively, of the flow of the exhaust gas G as seen along the direction thereof.

[0020] An exhaust muffler 20 according to the present disclosure has a silencer functionality to reduce the noise of the exhaust gas. In addition, the exhaust muffler 20 also has a so-called purification functionality with which it can limit the emission of harmful substances contained in the exhaust gas into the atmosphere. The "silencer functionality" in this context involves the attenuation of the pressure energy of the exhaust gas through the provision of a resonant structure and/or the formation of a plurality of compartments that facilitate repeated expansion and contraction of the exhaust gas. Further, the "purification functionality" involves the use of, for example, a platinum group element (i.e., a catalyst material), such as platinum (Pt), palladium (Pd), and rhodium (Rh) that are precious noble metals for conversion of harmful substances contained in the exhaust gas into non-harmful substances in a redox reaction between the platinum group element and the exhaust gas. More specifically, upon coming into contact with the platinum family element, nitrogen oxides (NOx), carbon monoxides (CO), and hydrocarbons (HC) among the harmful substances contained in the exhaust gas are respectively converted into non-harmful N_2, CO_2,

and H_2O.

[0021] The exhaust muffler 20 reduces the noise of the exhaust gas from the engine E of the motorcycle, and also, helps tune the engine characteristics. As shown in Fig. 2, the engine muffler 20 connects to the exhaust pipe 22 through a coupling pipe 27. The coupling pipe 27 lets the exhaust gas G pass therethrough, can be detachably coupled to the exhaust pipe 22 at an upstream end (or front end) thereof with the aid of a band or other means, and is welded to the exhaust muffler 20 at a downstream end (or rear end) thereof. The downstream end of the coupling pipe 27 is fitted with an upstream sensor 35 that detects a state of the exhaust gas G flowing through the coupling pipe 27. The upstream sensor 35 in the instant embodiment is an oxygen sensor that detects the content of oxygen in the exhaust gas G.

[0022] The exhaust muffler 20 includes a cylindrical muffler main body 28 and a muffler inlet 30. The muffler inlet 30 is connected with the coupling pipe 27 at an upstream end (or front end) thereof and adjoins the muffler main body 28 at a downstream end (or rear end) thereof. As shown in Fig. 3, the muffler main body 28 is provided, on the outer circumferential side thereof, with mounting sections 28a through which the muffler cover 24 (Fig. 2) is fastened. The mounting sections 28a in the instant embodiment are located in such a way that a downstream sensor, which will be discussed later, is interposed therebetween. More specifically, each of the mounting sections 28a has a weld nut into which a fastener such as a bolt can be screwed. Further, in the instant embodiment, two mounting sections 28a are provided and spaced apart in the front-to-rear direction. However, the embodiment only represents some of the non-limiting examples of the structure, the arrangement, and the number of the mounting sections 28a. The muffler main body 28 in the instant embodiment has a cylindrical shape with an elliptical, transverse cross section. It should be noted that the transverse cross-sectional shape of the muffler main body may be perfect-circular or substantially polygonal instead of being elliptical.

[0023] The muffler 20 includes: an inner tube 32 in which a silencer chamber SP is defined; and an outer tube 34 which forms the outer shell of the muffler 20. Therefore, the muffler main body 28 has a double structure of the inner tube 32 and the outer tube 34 which surrounds the radially outer side of the inner tube 32. In the instant embodiment, a sound absorber 36 is interposed between the inner tube 32 and the outer tube 34. The sound absorber 36 is realized by a porous material having a multitude of fine pores and voids formed therein. Examples of the sound absorber 36 used include a glasswool. The circumferential wall of the inner tube 32 is punched with holes. The exhaust gas G in the silencer chamber SP comes into contact with the sound absorber 36 through the punched holes. By arranging the sound absorber 36 in the exhaust muffler 20, it is possible to suppress the radiated sound from the outer tube 34 by the exhaust gas G. Further, the air space provided by the sound absorber 36 can suppress the increase in temperature of the surface of the outer tube 34 of the exhaust muffler 20.

[0024] The muffler inlet 30 is a conical element which has a diameter that gradually increases from the upstream end thereof where it is connected with the coupling pipe 27 towards the downstream end thereof where it connects to the muffler main body 28. More specifically, the downstream end of the coupling pipe 27 is inserted into and welded to the inner circumferential side of the upstream end of the muffler inlet 30. The downstream end of the muffler inlet 30 is inserted into and welded to the inner circumferential side of the upstream end of the muffler main body 28. In the instant embodiment, the interior of the muffler inlet 30 forms a part of the silencer chamber SP of the exhaust muffler 20. In other words, the front end of the silencer chamber SP is closed by the front end wall 30a of the muffler inlet 30.

[0025] The downstream end of the muffler inlet 30 connects to the upstream end of the outer tube 34. The muffler inlet 30 has an internal space in which the upstream end part of a pipe member is received. Having the internal space in which the pipe member is arranged, the muffler inlet 30 is designed to represent a double structure consisting of itself and the pipe member. In this way, the exhaust gas G from the coupling pipe 27 is prevented from directly flowing into the muffler inlet 30. The internal space of the muffler inlet 30 is in communication, at the downstream end thereof, with the internal space of the inner tube 32. Thus, the internal space of the muffler inlet 30 can be utilized to serve as a part of the silencer chamber.

[0026] The silencer chamber SP of the exhaust muffler 20 may be segmented into a plurality of silencer compartments. In the instant embodiment, the silencer chamber SP is segmented into three silencer compartments consisting of first to third silencer compartments 41, 42, 43. More specifically, the rear end of the silencer chamber SP is closed by a cap member 38, and the front end of the silencer chamber SP is closed by the muffler inlet 30. A first partition 44 and a second partition 46 on the front side and the rear side, respectively, are used to compartmentalize the silencer chamber SP. The cap member 38 is welded to the inner circumferential side of the rear part of the outer tube 34. The first and second partitions 44, 46 are welded to the inner circumferential side of the inner tube 32.

[0027] Starting from the front side, the silencer compartments 41, 42, 43 are arranged in the order of the second silencer compartment 42, the third silencer compartment 43, and the first silencer compartment 41. More specifically, the first silencer compartment 41 is formed within a portion of the internal space of the inner tube 32 which is situated between the cap member 38 and the second partition 46. The second silencer compartment 42 is formed within the internal spaces of the inner tube 32 and the muffler inlet 30 and is defined by the first partition 44 and the front end wall 30a of the muffler inlet 30. The

third silencer compartment 43 is formed within the internal space of the inner tube 32 and is defined by the first partition 44 and the second partition 46.

[0028] Pipe members 51 to 53 through which the exhaust gas G is allowed to pass are arranged within the silencer chamber SP of the exhaust muffler 20. The exhaust muffler 20 in the instant embodiment has three pipe members consisting of first through third pipe members 51 to 53.

[0029] The upstream end 51a of the first pipe member 51 is in communication with the downstream end of the coupling pipe 27. The first pipe member 51 extends from the upstream end 51a towards the downstream side in the direction of the flow, penetrates through the first and second partitions 44, 46, and is open to the first silencer compartment 41 at the downstream end 51b thereof. The first pipe member 51 will be later discussed in detail.

[0030] As shown in Fig. 5, the second pipe member 52 is open to the first silencer compartment 41 at the upstream end 52a thereof. The second pipe member 52 extends from the upstream end 52a towards the front, penetrates through the second partition 46 and the first partition 44, and is open to the second silencer compartment 42 at the downstream end 52b thereof. Further, a through hole 54 (Fig. 4), via which the second silencer compartment 42 and the third silencer compartment 43 communicate with each other, is provided in the first partition 44.

[0031] The third pipe member 53 is open to the third silencer compartment 43 at the entrance 53a thereof. In the instant embodiment, the front end of the third pipe member 53 is closed, and the entrance 53a is defined in the outer periphery of the third pipe member 53. The third pipe member 53 extends towards the rear by penetrating through the second partition 46 and is open to the outside of the exhaust muffler 50 at the downstream end 53b thereof. In the instant embodiment, the downstream end 53b of the third pipe member 53 communicates with an outlet pipe 56 which penetrates through the cap member 38. The outer periphery of the outlet pipe 56 is surrounded by an outlet cover 58 which is detachably attached to the cap member 38.

[0032] The exhaust gas G flows from the coupling pipe 27 into the first pipe member 51 of the exhaust muffler 20, goes on to flow through the first pipe member 51, and enters and expands in the first silencer compartment 41. Then, the exhaust gas G from the first silencer compartment 41 undergoes contraction as it flows through the second pipe member 52, and enters and expands in the second silencer compartment 42. In turn, the exhaust gas G from the second silencer compartment 42 contracts as it passes the through hole 54, and flows into and expands in the third silencer compartment 43. Finally, the exhaust gas G from the third silencer compartment 43 exits to the outside of the muffler via the third pipe member 53 and the outlet pipe 56.

[0033] Thus, the exhaust gas G loses its pressure energy as it experiences repeated expansions and contractions within the exhaust muffler 20. In this way, the noise emitted by the exhaust gas G when it exits to the outside of the exhaust muffler 20 is reduced. Also, a through hole may be provided in the second partition 46 to put the first silencer compartment 41 and the third silencer compartment 43 in communication with each other to reduce the noise of the exhaust gas G by facilitating the interference (or resonance) between the exhaust gas G flowing from the first silencer compartment 41 to the third silencer compartment 43 and the exhaust gas G flowing from the second silencer compartment 42 to the third silencer compartment 43.

[Flame Arrestor]

[0034] In the instant embodiment, the third pipe member 53 is provided with a flame arrestor 60. The flame arrestor 60 blocks flames while allowing gases to pass therethrough. In the instant embodiment, the flame arrestor 60 is a mesh fitted to the entrance 53a of the third pipe member 53.

[0035] In the instant embodiment, the third pipe member 53 is detachably arranged to enable maintenance of the flame arrestor 60. More specifically, a flange component 66 having an increasing diameter towards the rear is joined to a coupling member 64 which couples the third pipe member 53 to the outlet pipe 56. The flange component 66 and the cap member 38 are coupled in an overlapping manner in the front-to-rear direction with bolts 70 inserted from the rear, with the cap member 38 being in front of the flange component 66.

[0036] Also, an insertion pipe 62 having a larger diameter than that of the third pipe member 53 is arranged in a penetrating manner through the second partition 46. Having a diameter smaller than this, the third pipe member 53 is inserted through the interior of the insertion pipe 62 in a displaceable manner in the front-to-rear direction upon the loosening of the bolts 70. A seal member 69 is attached to the outer circumferential side of the third pipe member 53 in close contact with the inner circumferential side of the insertion pipe 62. The seal member 69 can prevent the ingress of the exhaust gas G from the first silencer compartment 41 to the third silencer compartment 43 through the gap between the outer circumferential side of the third pipe member 53 and the inner circumferential side of the insertion pipe 62.

[0037] It should be noted, however, that the flame arrestor 60 may be omitted from the third pipe member 53. In this case, the insertion pipe 62 can also be omitted, and the third pipe member 53 and the outlet pipe 56 may be welded to the second partition 46 and the cap member 38, respectively.

[Catalytic Converter]

[0038] A catalytic converter 72 is disposed in the first pipe member 51. The catalytic converter 72 purifies harmful components contained in the exhaust gas G.

More specifically, the first pipe member 51 has a catalyst accommodating section 74 which has an enlarged diameter and in which the catalytic converter 72 is accommodated. The catalyst accommodating section 74 has the largest diameter of the first pipe member 51. The first pipe member 51 has an upstream section 76 which is located upstream of the catalyst accommodating section 74. Also, the first pipe member 51 has a downstream section 80 which is located downstream of the catalyst accommodating section 74.

[0039] The upstream section 76 upstream of the catalyst accommodating section 74 in the first pipe member 51 is in communication with the coupling pipe 27 at the upstream end thereof. In other words, the upstream end of the upstream section 76 forms the upstream end 51a of the first pipe member 51. The upstream section 76 has a diameter which gradually increases from the upstream end 51a towards the catalyst accommodating section 74.

[0040] The axis of the upstream section 76 slants radially outwards with respect to the outer tube 34 as they extend towards the rear. Also, the upstream section 76 is designed as a "shell-to-shell structure" in which upper and lower split bodies mate each other to form the upstream section 76. This allows the upper and lower bodies to be formed in asymmetrical shapes. The lower body of the upstream section 76 is formed to have a diameter which increases to a lesser degree than the diameter of the upper body of the upstream section 76 as they extend towards the downstream side thereof. Since the lower body of the upstream section 76 is thus formed with a moderate inclination, it is possible to suppress the cross-sectional change in the direction of the flow, thereby helping keep the exhaust gas G from becoming turbulent.

[0041] An inlet pipe 75 is arranged inside the upstream section 76. The inlet pipe 75 is welded to the inner circumferential side of the upstream section 76. The front end 75a of the inlet pipe 75 faces the coupling pipe 27. Hence, the exhaust gas G from the coupling pipe 27 is introduced into the inlet pipe 75. The rear end 75b of the inlet pipe 75 is closed, and the circumferential wall of the inlet pipe 75 is punched with a plurality of holes 75c. Therefore, the exhaust gas G introduced into the inlet pipe 75 radially exits through the punched holes 75c. In other words, the inlet pipe 75 forms a defector located upstream of the catalytic converter 72 to radially deflect the flow of the exhaust gas G.

[0042] The downstream section 78 downstream of the catalyst accommodating section 74 in the first pipe member 51 includes a shrinking segment 80 having a diameter that decreases towards the downstream side thereof and an extended segment 82 adjoining the downstream end of the shrinking segment 80. The shrinking segment 80 is designed as a "shell-to-shell structure" in which upper and lower split bodies mate each other to form the shrinking segment 80. This allows the upper and lower bodies to be formed in asymmetrical shapes. The upper body of the shrinking segment 80 is formed to have a diameter which increases to a lesser degree than the diameter of the lower body of the shrinking segment 80 as they extend towards the downstream side thereof. Since the upper body of shrinking segment 80 is thus formed with a moderate inclination, it is possible to suppress the cross-sectional change in the direction of the flow, thereby helping keep the exhaust gas G from becoming turbulent. Further, since the upper body of the shrinking segment 80 is formed with a moderate inclination and possibly formed in a planar manner, its connection with a closure which will be discussed later can be established more easily.

[0043] More specifically, the downstream section 78 is arranged more proximate to the inner wall of the outer tube 34 than the upstream section 76 is. Even more specifically, a portion of the shrinking segment 80 which faces the inner wall of the outer tube 34 extends in an aligned manner along the outer tube 34, while a portion of the shrinking segment 80 which faces away from the inner wall of the outer tube 34 extends towards the downstream side thereof by slanting in a direction that radially approaches the outer tube 32. Thus, the shrinking segment 80 as a whole defines an axis which extends towards the downstream side thereof by slanting in a direction that radially approaches the inner wall of the outer tube 34.

[0044] The downstream section 78 has the largest diameter at the upstream end of the shrinking segment 80. The downstream end of the shrinking segment 80 and the extended segment 82 connected therewith have respective channels with identical cross-sectional areas. The extended segment 82 extends with a channel having a constant cross-sectional area from the shrinking segment 80 towards the downstream side thereof. In other words, the extended segment 82 is formed as a portion of the first pipe member 51 which is located downstream of the shrinking segment 80 in such a way to extend in an aligned manner along the outer tube 34. The downstream end of the extended segment 82 is open to the second silencer compartment 42. Thus, the downstream end of the downstream section 78 forms the downstream end 51b of the first pipe member 51. A straight segment spanning a certain length should be provided as a segment located downstream of the catalytic converter 72. In the instant embodiment, the extended segment 82 serves as the straight segment. For instance, the extended segment 82 may be formed with a volume larger than a per-cylinder combustion volume. Further, the extended segment 82 may be formed with a length longer than the diameter of the catalytic converter 72.

[Sensor]

[0045] As shown in Fig. 4, the exhaust muffler 20 is fitted with the downstream sensor 84. The downstream sensor 84 detects a state of the exhaust gas G flowing through the first pipe member 51. In the instant embodiment, the downstream sensor 84 is an oxygen sensor

that detects the content of oxygen in the exhaust gas G. As shown in Fig. 2, the downstream sensor 84 is externally covered by the muffler cover 24. In this way, possible collisions of obstacles into the downstream sensor 84 can be avoided. By using the muffler cover 24 to cover the downstream sensor 84, it is possible to obviate the need to provide a dedicated component that covers the downstream sensor 84. Further, despite the fact that off-road vehicles such as that of the instant embodiment have more tendency to be subjected to dirt, water, etc., the muffler cover 24 provides a cover for the downstream sensor 84 and, therefore, protects the same against dirt and water in the instant embodiment.

[0046] As shown in Fig. 4, the upstream sensor 35 is arranged upstream of the catalytic converter 72 and the downstream sensor 84 is arranged downstream of the catalytic converter 72 in the instant embodiment. The upstream sensor 35 is used, for example, for fuel injection control (or air-fuel ratio control). The downstream sensor 84 is used, for example, for failure diagnosis of the catalytic converter 72.

[0047] The downstream sensor 84 is inserted into the shrinking segment 80 of the first pipe member 51. More particularly, the downstream sensor 84 is inserted into a portion of the pipe which is located downstream of the downstream end of the catalyst accommodating section 74 and which has a diameter smaller than that of the catalyst accommodating section 74. In the instant embodiment, an inserting portion 86 of the first pipe member 51 into which the downstream sensor 84 is inserted is a portion of the first pipe member 51 which is the most proximate to the inner tube 32 and the outer tube 34 and which has a diameter smaller than that of the catalyst accommodating section 74. In other words, the downstream sensor 84 is positioned at a point of the channel which is located downstream of the catalytic converter 72 with a narrowed cross-sectional area. Thus, since the downstream sensor 84 is arranged in a zone located downstream of the catalytic converter 72 with an increased concentration of the exhaust gas G, the exhaust gas G can come into contact with the sensor in a radially densified manner and can thereby suppress signal variations.

[0048] Further, the narrowing of the cross-sectional area of the channel is done towards where the downstream sensor 84 is inserted. More specifically, the axis X1 of the downstream section 78 extends towards the downstream side thereof by slanting relative to the axis AX of the exhaust muffler 22 in such a way to approach the downstream sensor 84. Furthermore, the central point O1 of the inserting portion 86 is offset radially outwards from the central point of the outer tube 34 (or the axis AX of the exhaust muffler 22).

[Mounting Structure for Downstream Sensor]

[0049] A mounting structure for the downstream sensor 84 will be discussed in connection with Fig. 7. The downstream sensor 84 has a shaft-like form. The downstream sensor 84 has a sensing unit which is provided at one of the axial ends of the sensor 84. The sensing unit of the downstream sensor 84 extends through the outer tube 34 and the inner tube 32 of the exhaust muffler 20 and is positioned inside the shrinking segment 80 of the first pipe member 51. The downstream sensor 84 is fitted to the shrinking segment 80 in such a way that the sensing unit is positioned in the internal space of the shrinking segment 80. More specifically, the sensing unit of the downstream sensor 84 extends through a muffler opening 90 defined in the outer tube 34 of the exhaust muffler 20 and is fitted into a pipe opening 92 defined in the inserting portion 86 of the first pipe member 51. Even more specifically, the downstream sensor 84 is screwed into a cylindrical boss element 94 welded to the pipe opening 92.

[0050] Since a radial gap is defined between the extended segment 82 and the inner tube 32, there is a chance that the exhaust gas G enters and flows through the gap and moves towards an opening which is defined in the inner tube 32 and which is used for the insertion of the sensor. In the instant embodiment, even if the exhaust gas G has escaped out of the inner tube 32 through this opening in the inner tube 32, the blockage provided by the outer tube 34 and a closure 88 (which will be discussed later) prevents the exhaust gas G from subsequently leaking from around the sensor 84.

[0051] The opening formed in the inner tube 32, too, allows the insertion of the sensing unit of the downstream sensor 84. The opening formed in the inner tube 32 has such a size that allows features including the closure 88 to be arranged therein. In other words, the sites of the closure 88 which are welded to the first pipe member 51 are contained within the extension of the opening formed.

[0052] The exhaust muffler 20 includes the closure 88 to close the muffler opening 90 of the outer tube 34. As shown in Fig. 3, the closure 88 is disposed around the downstream sensor 84 to block the exhaust gas G inside the silencer chamber SP from escaping into the external environment. The closure 88 in the instant embodiment is formed of a bent metal sheet and, when viewed along the axis X2 of the downstream sensor 84, has an elliptical shape with a major axis aligned in the longitudinal direction D1 of the exhaust muffler 20. While the closure 88 is formed from a metal material in the instant embodiment, the instant embodiment only represents some of the non-limiting examples of the material and shape of the closure 88. The closure 88 may have any structure as long as it can close those openings that are formed to allow the insertion of the sensor.

[0053] The closure 88 includes, at the center thereof, a recess 96 which is depressed towards the silencer chamber SP. More specifically, the closure 88 includes a slope 98 that gradually depresses towards the center from the outer edge thereof to connect to the recess 96. The depression depth of the closure 88 relative to the outer tube 34 is not fixed, but varies at different circumferential

points on the closure 88. In the instant embodiment, the closure 88 is depressed relative to the outer tube 34 with a depression depth which, when the muffler 20 is mounted to the vehicle, decreases towards one of the widthwise outer sides of the vehicle (or the right side in the instant embodiment). In this way, it is possible to keep water from accumulating in the recess 96 when the vehicle is kept sitting on a side stand.

[0054] As shown in Fig. 6, the closure 88 includes a pipe-side connection 100 at which the closure 88 is coupled to the first pipe member 51 and an outer tube-side connection 102 at which the closure 88 is coupled to the outer tube 34. In other words, the closure 88 is coupled to the first pipe member 51 which is the radially innermost component and is coupled to the outer tube 34 which is the radially outermost component, but is not coupled to the inner tube 32 which is situated between these two components.

[0055] The pipe-side connection 100 is where the closure 88 is coupled in a radially overlapping manner to a portion of the first pipe member 51 which adjoins the pipe opening 92. Meanwhile, the outer tube-side connection 102 is where the closure 88 is coupled in a radially overlapping manner to a portion of the outer tube 34 which adjoins the muffler opening 90. That is, the outer tube-side connection 102 represents a first element 102 that couples to a portion of the outer tube 34 which adjoins the muffler opening 90, in a radially overlapping manner therewith, and the pipe-side connection 100 represents a second element 100 that couples to a portion of the first pipe member 51 which adjoins the pipe opening 92, in a radially overlapping manner therewith.

[0056] While the closure 88 is processed as a single bent metal sheet in the instant embodiment, the outer tube-side connection (or the first element) 102 and the pipe-side connection (or the second element) 100 may be formed as separate pieces and coupled to each other at axially overlapping portions thereof.

[0057] The portion 86 of the first pipe member 51, that is, a portion of the first pipe member 51 where the pipe opening 92 is formed, has a flat surface extending perpendicular to the axis X2 of the downstream sensor 84. The pipe-side connection 100 has a planar surface that aligns with the flat surface, and the flat surface of the first pipe member 51 and the planar surface of the pipe-side connection 100 are welded to each other in a radially overlapping manner. In this process, the first pipe member 51 and the pipe-side connection 100 of the closure 88 can be moved relative to each other along the flat surface and the planar surface to accommodate axial misalignment (in a direction perpendicular to the sheet of Fig. 6). In other words, the pipe-side connection 100 provides an axial joining margin at the time of their joining.

[0058] The outer tube-side connection 102 is formed of the outer edge of the closure 88 that is bent radially inwards to extend towards the silencer chamber SP. In the instant embodiment, the outer tube-side connection 102 is coupled to the outer tube 34 through a coupling member 104. The coupling member 104 is formed of a metal sheet which is bent to have a V-shaped cross section.

[0059] One 104a of the legs of the V shape, in which the coupling member 104 is bent, is welded to the outer circumferential side of the outer tube 34. More specifically, the one leg 104a extends circumferentially along the outer circumferential surface of the outer tube 34, and the one leg 104a and the circumferential surface of the outer tube 34 are welded to each other in a radially overlapping manner. In this process, the one leg 104a of the coupling member 104 and the outer tube 34 can be moved circumferentially relative to each other to accommodate circumferential misalignment. In other words, the one leg 104a of the coupling member 104 provides a circumferential joining margin at the time of their joining.

[0060] The other 104b of the legs of the V shape, in which the coupling member 104 is bent, is welded to the outer tube-side connection 102 of the closure 88. More specifically, the other leg 104b extends radially towards the silencer chamber SP, and the other leg 104b and the outer tube-side connection 102, both of which extend radially, are welded to each other in a circumferentially overlapping manner. In this process, the other leg 104b of the coupling member 104 and the outer tube-side connection 102 of the closure 88 can be moved radially relative to each other to accommodate radial misalignment. In other words, the other leg 104b of the outer tube-side connection 102 provides a radial joining margin at the time of their joining.

[0061] The closure 88 may have any structure as long as it can accommodate the radial, circumferential, and axial misalignment between the outer tube 34 and the first pipe member 51. The instant embodiment only represents one of the non-limiting examples of the structure of the closure 88.

[0062] As shown in Fig. 4, a restrictor wall 106 is arranged between the inner tube 32 and the outer tube 34 near where the downstream sensor 84 is mounted. The restrictor wall 106 is a component having an L-shaped cross section and restricts displacement of the filler 36 towards the muffler opening 90. The restrictor wall 106 is arranged along the downstream sensor 84, that is, along the muffler opening 90, to prevent the filler 36 between the inner tube 32 and the outer tube 34 from being displaced out of position towards the muffler opening 90.

[0063] As shown in Fig. 7, the closure 88 is welded to the first pipe member 51 at a weld site W1. Also, the closure 88 is welded to the outer tube 34 at a weld site W2. The first pipe member 51 and the outer tube 34 are welded and closed along the entire circumference with the aid of the closure 88. Hence, gases inside the silencer chamber SP are prevented from escaping into the external environment. The inner tube 32 is not welded to the closure 88, and a gap may be present between these components 32, 88. Such a gap can be used to accommodate possible assembly errors. The catalytic converter 74 and the first pipe member 51 may be designed to be

slidable.

[0064] According to this configuration, the closure 88 is not coupled to the inner tube 32, but is coupled to the first pipe member 51 and the outer tube 34. Therefore, the downstream sensor 84 can be allowed to be mounted to the exhaust muffler 20 in such a manner that accommodates possible assembly errors between the inner tube 32 and the outer tube 34 and possible difference in thermal expansion between the inner tube 32 and the outer tube 34. More specifically, the relative positions of the first pipe member 51 and the outer tube 34 can be adjusted using the joining margins provided by the closure 88 in order to address possible assembly errors that may occur at the time of joining of the inner tube 32 and the outer tube 34. As a result, the downstream sensor 84 can be stably mounted to the exhaust muffler 22 which has a double structure.

[0065] Further, since the closure 88 is designed to couple the first pipe member 51 and the outer tube 34, the inner tube 32, which has a larger size than the first pipe member 51, does not need to have a feature to allow a component to be coupled to the closure 88, thereby allowing the structure of the inner tube 32 to be simplified. Furthermore, since the downstream sensor 84 is fitted to the first pipe member 51 to detect a state of the exhaust gas G flowing through the first pipe member 51, a higher detection accuracy can be achieved than when providing the downstream sensor 84 on the inner tube 32 by avoiding a turbulent flow of the exhaust gas G.

[0066] As shown in Fig. 4, in the instant embodiment, the inserting portion 86 of the first pipe member 51 into which the downstream sensor 84 is inserted defines an axis AX2 pointing radially outwards from the axis AX of the outer tube 34. According to this configuration, the first pipe member 51 can be disposed in close proximity to the circumferential surface of the outer tube 34, thereby making it possible for the insertion depth of the downstream sensor 84 from the outer tube 34 to be shallower.

[0067] As shown in Fig. 6, in the instant embodiment, the closure 88 includes the first element 102 (or the outer tube-side connection 102) at which the closure 88 is coupled to a portion of the outer tube 32 which adjoins the muffler opening 90, in a circumferentially overlapping manner therewith, and the second element 100 (or the pipe-side connection 100) at which the closure 88 is coupled to a portion of the first pipe member 51 which adjoins the pipe opening 92, in a radially overlapping manner therewith. According to this configuration, the outer tube-side connection 102 provides a radial joining margin, and the pipe-side connection 100 provides an axial joining margin.

[0068] Also, in the instant embodiment, the closure 88 is designed to be radially overlapped with the circumferential surfaces of the first pipe member 51 and the outer tube 34. Alternatively, for instance, the first pipe member 51 and the outer tube 34 may be formed with respective axially protruding ribs, and the closure 88 may be designed to be axially overlapped with these protruding ribs. Nevertheless, the radially overlapping design of the closure 88 as in the instant embodiment obviates the need to form radially protruding ribs on the outer tube 34 and the first pipe member 51, thereby facilitating the simplified structures of the outer tube 34 and the first pipe member 51.

[0069] As shown in Fig. 4, in the instant embodiment, a portion of the first pipe member 51 that is located upstream of the inserting portion 86 of the first pipe member 51 into which the downstream sensor 84 is inserted defines an axis AX1 extending towards the inserting portion 86 by slanting in a direction that radially approaches the opening 102 in the outer tube 32. According to this configuration, the first pipe member 51 can be disposed in close proximity to the outer tube 34, thereby making it possible for the insertion depth of the downstream sensor 84 from the outer tube 34 to be shallower.

[0070] In the instant embodiment, the inserting portion 86 of the first pipe member 51 into which the downstream sensor 84 is inserted has a diameter smaller than that of the inlet 76 of the first pipe member 51. According to this configuration, the concentration of the exhaust gas G inside the first pipe member 51 can be increased in the vicinity of the downstream sensor 84, thereby making it possible to improve its detection accuracy.

[0071] In the instant embodiment, the first pipe member 51 has the extended segment 82 that is formed to extend as a downstream extension along the axis AX of the exhaust muffler 20 from the inserting portion 86 of the first pipe member 51 into which the downstream sensor 84 is inserted. According to this configuration, the outlet 51b of the first pipe member 51 can be spaced a certain distance apart from the inserting portion 86 to prevent a possible backflow of the exhaust gas G from the outlet 51b caused by exhaust gas pulsation from reaching the downstream sensor 84, thereby allowing its detection accuracy to be improved.

[0072] In the instant embodiment, the catalytic converter 72 is located in the first pipe member 51 and upstream of the inserting portion 86 of the first pipe member 51 into which the downstream sensor 84 is inserted. According to this configuration, the catalytic converter 72 and the downstream sensor 84 can be both supported on the first pipe member 51.

[0073] In the instant embodiment, the deflector 75 is located upstream of the catalytic converter 72 in the first pipe member 51 to radially deflect the flow of the exhaust gas G. According to this configuration, the exhaust gas G is prevented from directly hitting the catalytic converter 72 to protect the catalytic converter 72.

[0074] In the instant embodiment, to address possible reduction of the space available for the silencer chamber SP by the presence of the catalytic converter 72, the interior of the muffler inlet 30 located upstream of the muffler main body 28 is also utilized as part of the silencer chamber SP and the catalytic converter 72 is partially situated in the muffler inlet 30. Further, the inlet pipe 75 punched with the holes 75c is arranged upstream of the

catalytic converter 72 within the muffler inlet 30 to radially diffuse the exhaust gas G. In this way, the space for the silencer chamber SP can be secured. Also, the exhaust gas G is diffused to flow uniformly into the catalytic converter 72

[0075] In the instant embodiment, the closure 88 is depressed relative to the outer tube 34 with a depression depth which, when the exhaust muffler 20 is mounted to a vehicle body as in Fig. 3, decreases towards one of the widthwise sides of the motorcycle. According to this configuration, it is possible to keep water from accumulating in the recess 96 when the motorcycle is kept sitting on a side stand.

[0076] In the instant embodiment, the muffler cover 24 is provided to externally cover at least a part of the outer tube 34 such that the downstream sensor 84 is externally covered by the muffler cover 24. According to this configuration, by using the muffler cover 24 to cover the downstream sensor 84, the downstream sensor 84 can be protected without having to provide a dedicated component to protect the downstream sensor 84, thereby making it possible for the parts count to be reduced.

[0077] As shown in Fig. 4, in the instant embodiment, the sound absorber (filler) 36 is filled between the inner tube 32 and the outer tube 34, and the restrictor wall 106 is arranged near where the downstream sensor 84 is mounted to restrict displacement of the sound absorber 36. According to this configuration, the tendency of the sound absorber 36 to displace out of position due to the presence of the opening formed in the inner tube 32 can be counteracted by the restrictor wall 106.

[0078] The above embodiment only represents some of the non-limiting examples of the number and position of the catalytic converter(s) 72. While only a single catalytic converter 72 is provided and is disposed internally to the exhaust muffler 20 in the above embodiment, there may be more than one catalytic converter 72 and at least one of them may be disposed externally to the muffler. Further, the catalytic converter 72 may not necessarily be disposed internally to the exhaust muffler 20.

[0079] Alternatively, the closure 88 may be non-circular, e.g., rectangular. Also, the closure 88 may extend into the first pipe member 51. Further, the first pipe member 51 may adopt a "shell-to-shell structure" of upper and lower split bodies. Furthermore, instead of the boss used for fixation of the sensor being fixed to the first pipe member 51, the boss used for fixation of the sensor may be defined on the side of the closure 88. Even in this case, the closure 88 and the first pipe member 51 are welded along the entire circumference to prevent possible leakage of the exhaust gas G.

[0080] The above implementations are only some of the non-limiting examples of the present disclosure. Various additions, modifications, or omissions can be made therein without departing from the principle of the present disclosure. For instance, an oxygen sensor used in the above embodiment to detect the content of oxygen in the exhaust gas is only one of the non-limiting examples of the exhaust gas sensor. Other examples of the exhaust gas sensor can include a temperature sensor that detects the temperature of the exhaust gas, a flow velocity sensor that detects the flow velocity of the exhaust gas, and a pressure sensor that detects the pressure of the exhaust gas.

[0081] While the above embodiment illustrates an example arrangement of the downstream sensor 84 into the exhaust muffler 22, the upstream sensor 35 can also be positioned and fixed into the exhaust muffler 22 by utilizing the above-explained features. Also, a different type of sensor or other structures than the exhaust gas sensor can be used in an analogous manner as well.

[0082] A relatively small saddled-riding vehicle with a seat on which a driver can be seated in a straddled position is only one of the non-limiting examples of the vehicle to which an exhaust muffler according to the present disclosure can be installed. For instance, a four-wheeled vehicle in which passengers can be seated side-by side in the widthwise direction may be employed as the vehicle. Also, an exhaust muffler according to the present disclosure may be employed on a hybrid vehicle with an internal combustion engine and an electric motor. Preferably, an exhaust muffler according to the present disclosure can be suitably employed on a vehicle that would externally expose at least a part of the outer tube of the muffler.

[0083] An exhaust muffler according to the present disclosure can be employed as an exhaust muffler having a double structure of an inner tube and an outer tube. In other words, an exhaust muffler according to the present disclosure can even be employed as an exhaust muffler having a triple structure of a pipe member, an inner tube, and an outer tube. Thus, there are non-limiting options for the layout of the muffler on a vehicle. The exhaust muffler may be disposed on only one of the widthwise outer sides of the rear wheel or on both of the widthwise outer sides of the rear wheel. Alternatively, the exhaust muffler may be disposed immediately above the rear wheel or may be disposed between the rear wheel and the engine to serve as an exhaust chamber. Further, the compartmentalized design of the silencer compartments according to the above embodiment is described herein merely by way of example. Instead, any other conventional structures can also be used as long as they have a triple structure of an outer tube, an inner tube, and a pipe member, and are, thus, encompassed within the scope of the present disclosure.

Claims

1. A vehicle exhaust muffler, the muffler comprising:

an inner tube in which a silencer chamber is defined;
an outer tube forming an outer shell of the muffler;

a pipe member which is disposed in the silencer chamber and through which exhaust gas is allowed to pass;
a sensor which detects a state of the exhaust gas flowing through the pipe member; and
a closure disposed around the sensor to block gases inside the silencer chamber from escaping into an external environment, the closure including a pipe-side connection at which the closure is coupled to the pipe member and an outer tube-side connection at which the closure is coupled to the outer tube.

2. The vehicle exhaust muffler as claimed in claim 1, wherein an inserting portion of the pipe member, into which the sensor is inserted, defines an axis pointing radially outwards from an axis of the outer tube.

3. The vehicle exhaust muffler as claimed in claim 1 or 2, wherein
the closure comprises:

a first element which couples to a portion of the outer tube which adjoins an opening in the outer tube, in a circumferentially overlapping manner therewith; and
a second element which couples to a portion of the pipe member which adjoins an opening in the pipe member, in a radially overlapping manner therewith, and
the first element and the second element are coupled to each other at axially overlapping portions thereof.

4. The vehicle exhaust muffler as claimed in any one of claims 1 to 3, wherein a portion of the pipe member that is located upstream of an inserting portion into which the sensor is inserted defines an axis extending towards the inserting portion, by slanting in a direction that radially approaches an opening in the outer tube.

5. The vehicle exhaust muffler as claimed in any one of claims 1 to 4, wherein an inserting portion of the pipe member into which the sensor is inserted has a diameter smaller than that of an inlet of the pipe member.

6. The vehicle exhaust muffler as claimed in any one of claims 1 to 5, wherein the pipe member has an extended segment that is formed to extend as a downstream extension from an inserting portion of the pipe member into which the sensor is inserted.

7. The vehicle exhaust muffler as claimed in any one of claims 1 to 6, further comprising:
a catalytic converter located in the pipe member and upstream of an inserting portion of the pipe member into which the sensor is inserted.

8. The vehicle exhaust muffler as claimed in claim 7, further comprising:
a defector located upstream of the catalytic converter in the pipe member to radially deflect a flow of the exhaust gas.

9. The vehicle exhaust muffler as claimed in any one of claims 1 to 8, wherein the closure is depressed relative to the outer tube with a depression depth which, when the muffler is mounted to the vehicle, decreases towards one side in a widthwise direction of the vehicle.

10. The vehicle exhaust muffler as claimed in any one of claims 1 to 9, further comprising:
a muffler cover externally covering at least a part of the outer tube such that the sensor is externally covered by the muffler cover.

11. The vehicle exhaust muffler as claimed in any one of claims 1 to 10, further comprising:

a filler filled between the inner tube and the outer tube; and
a restrictor wall arranged near where the sensor is mounted to restrict displacement of the filler.

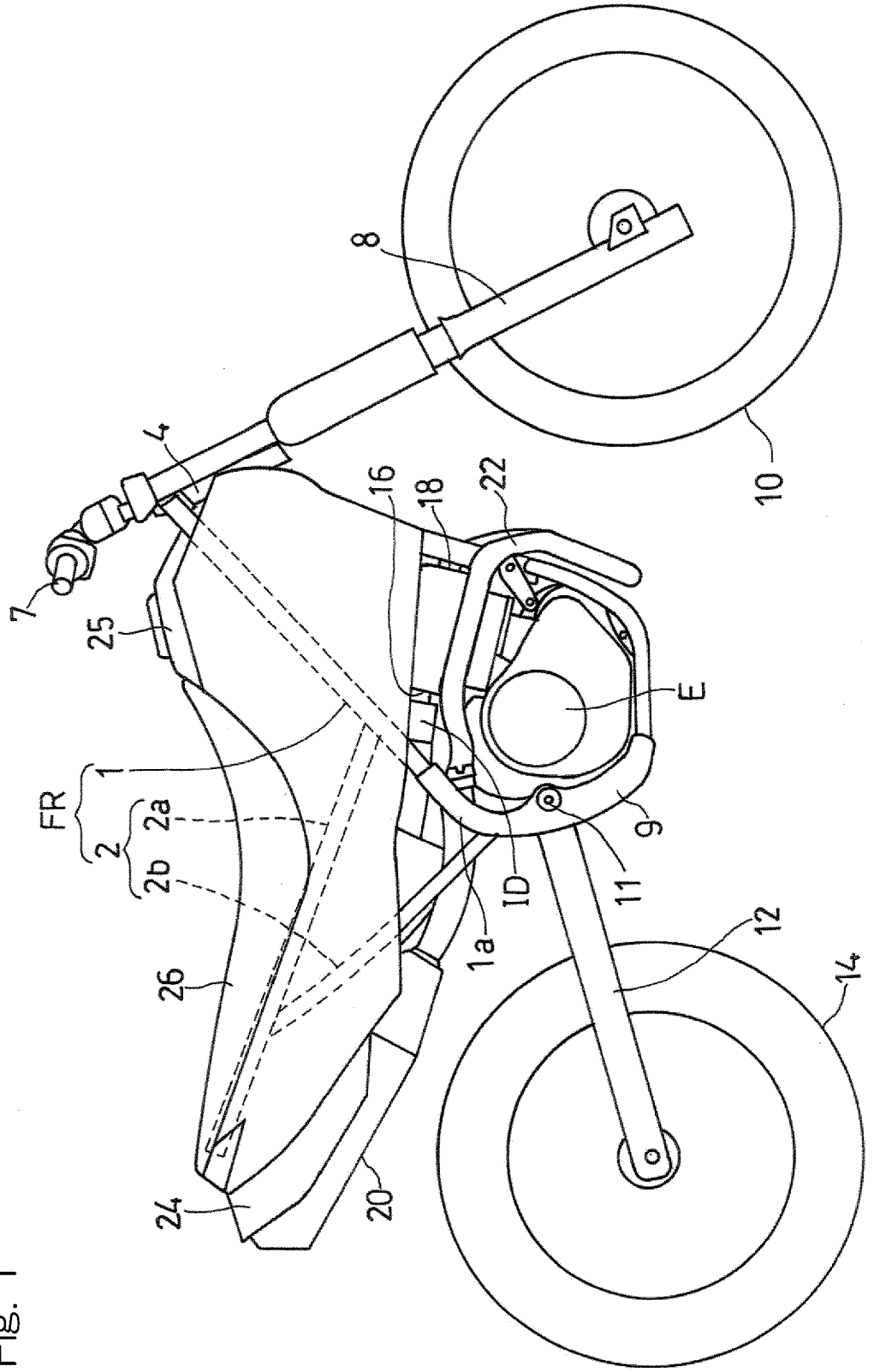

Fig. 1

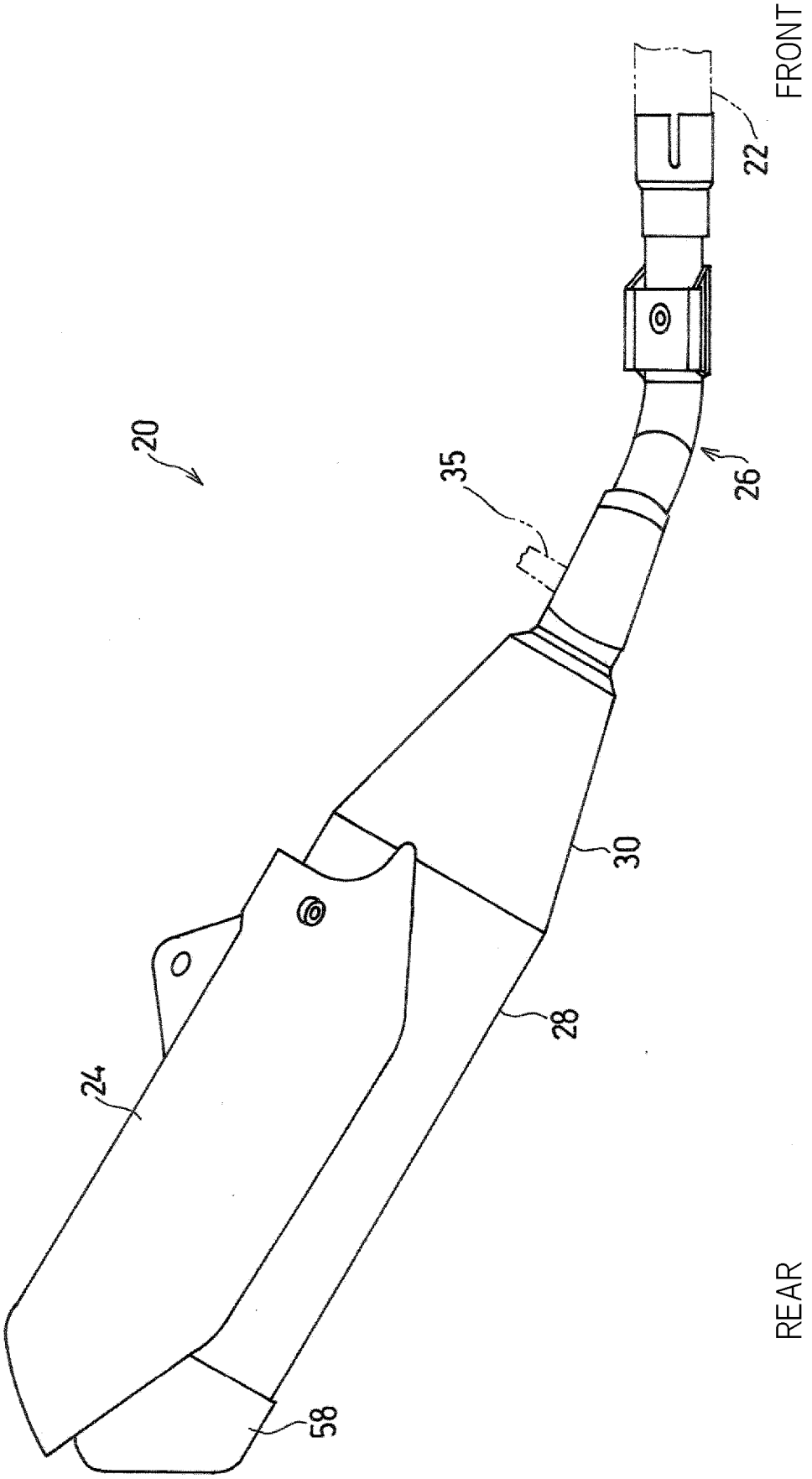

Fig. 2

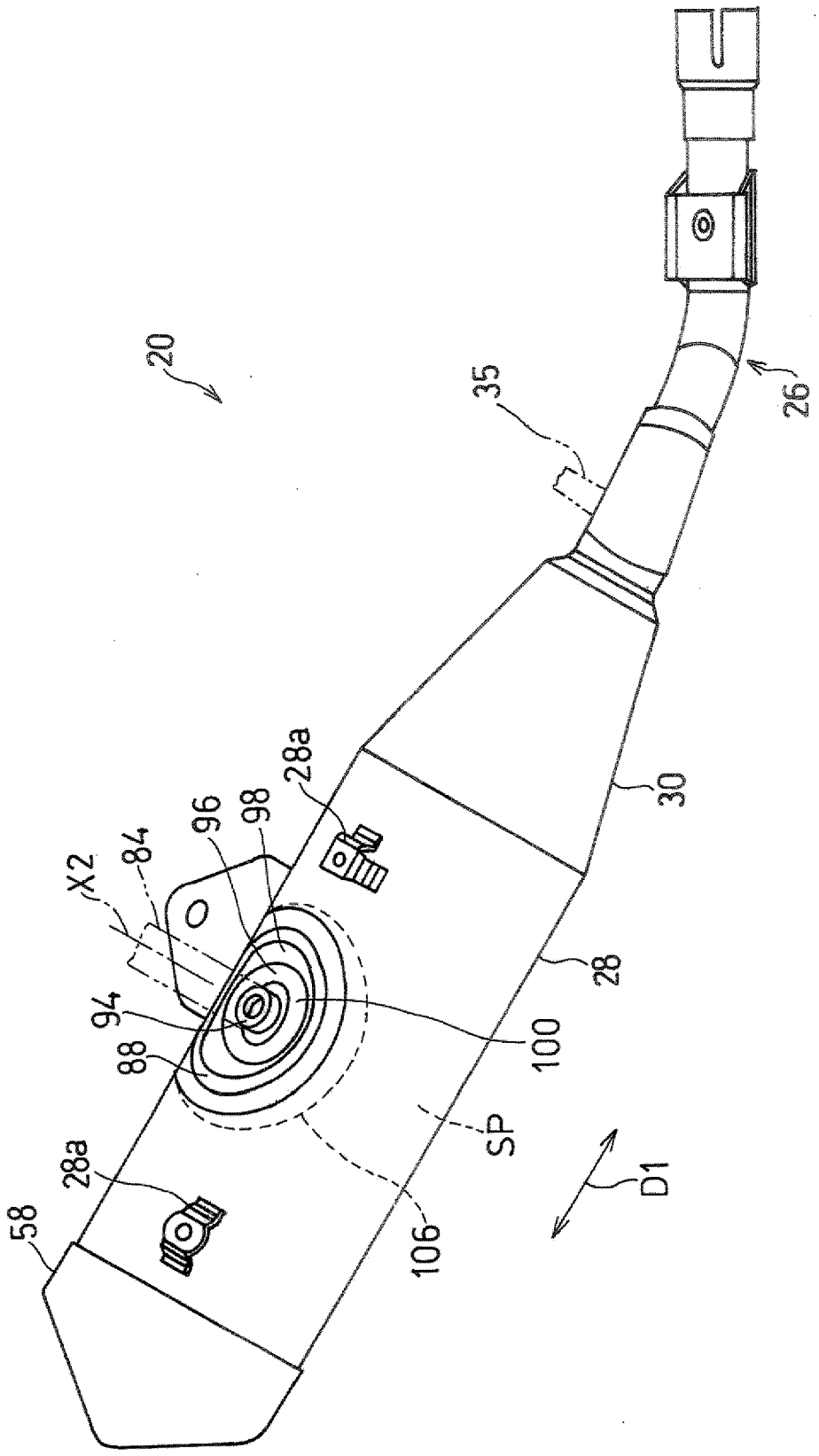

Fig. 3

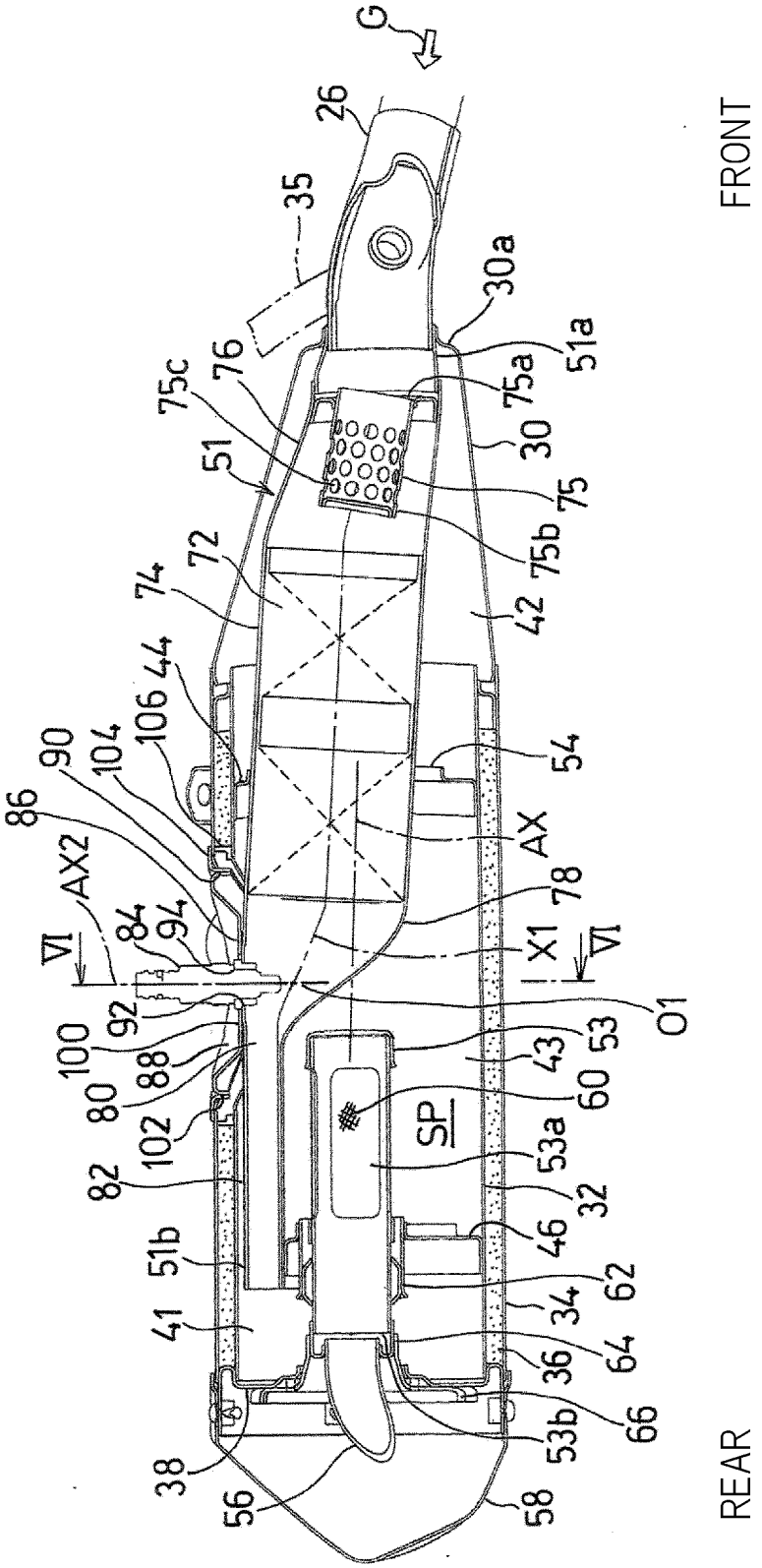
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Fig. 4

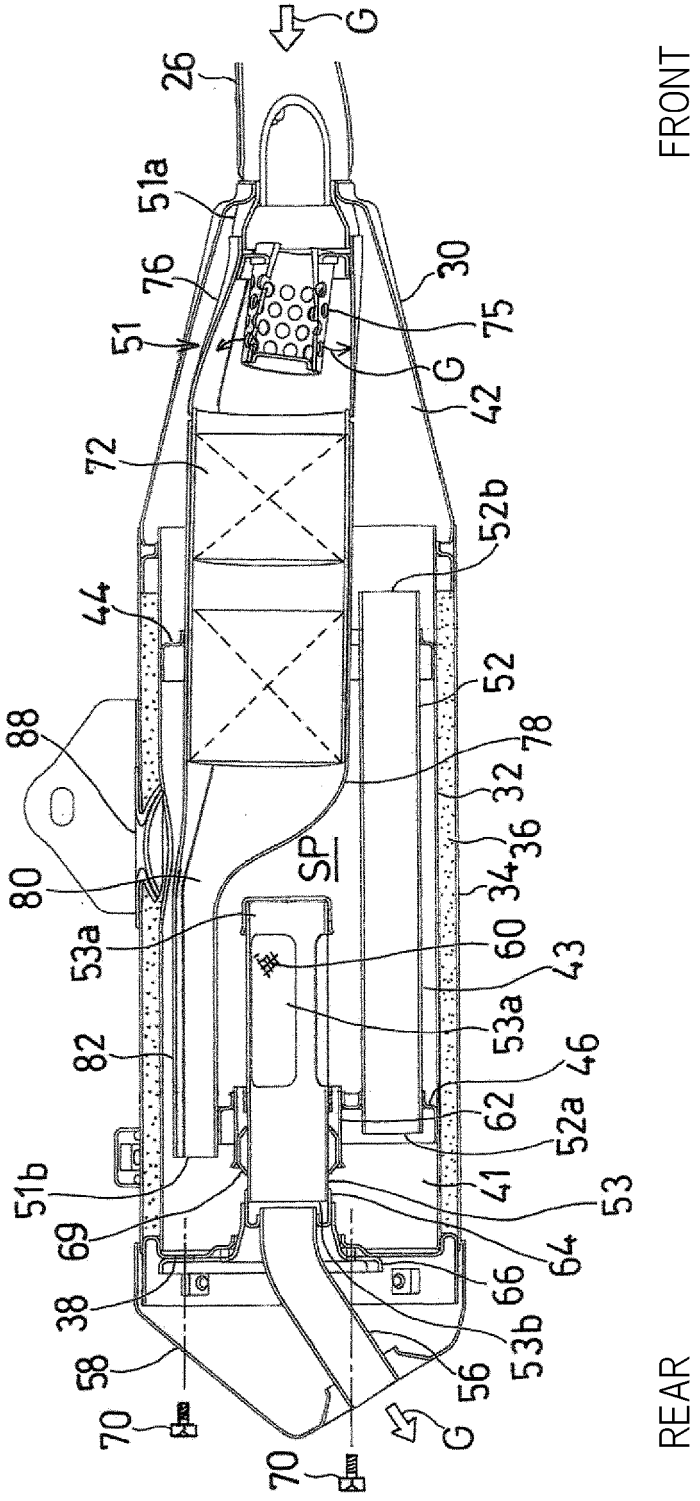
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Fig. 5

Fig. 6

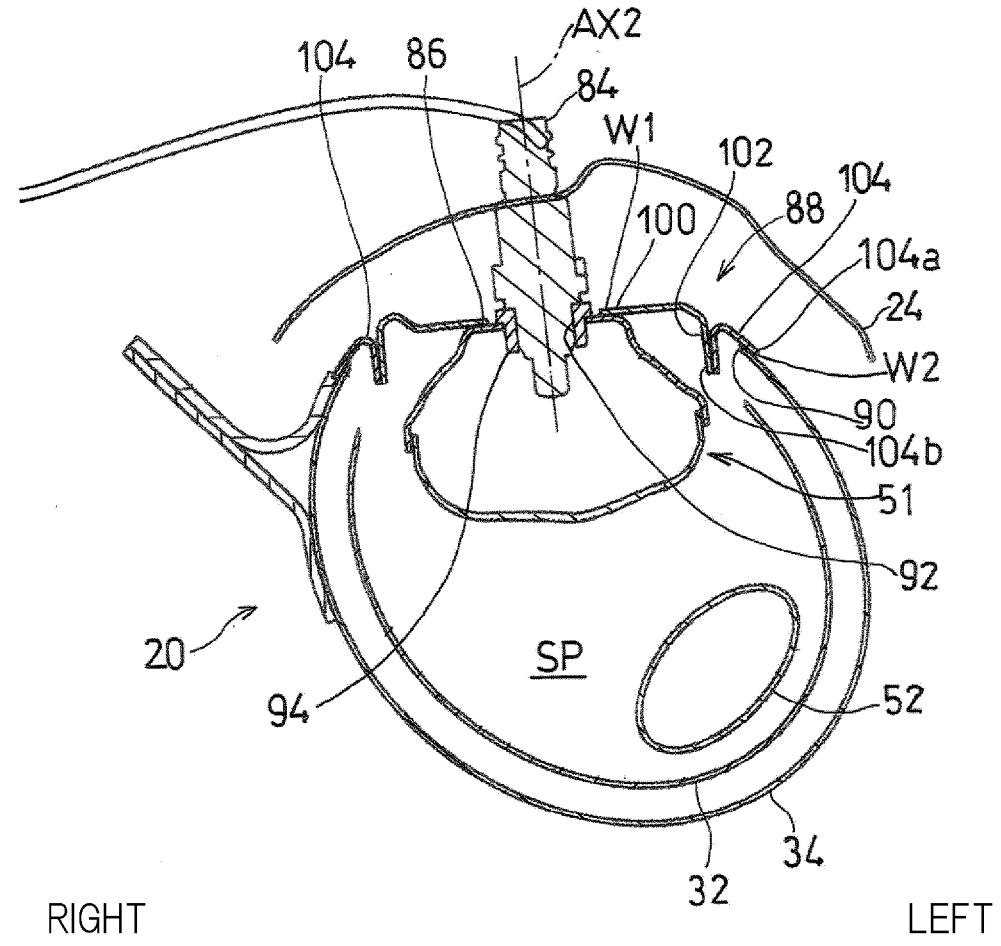
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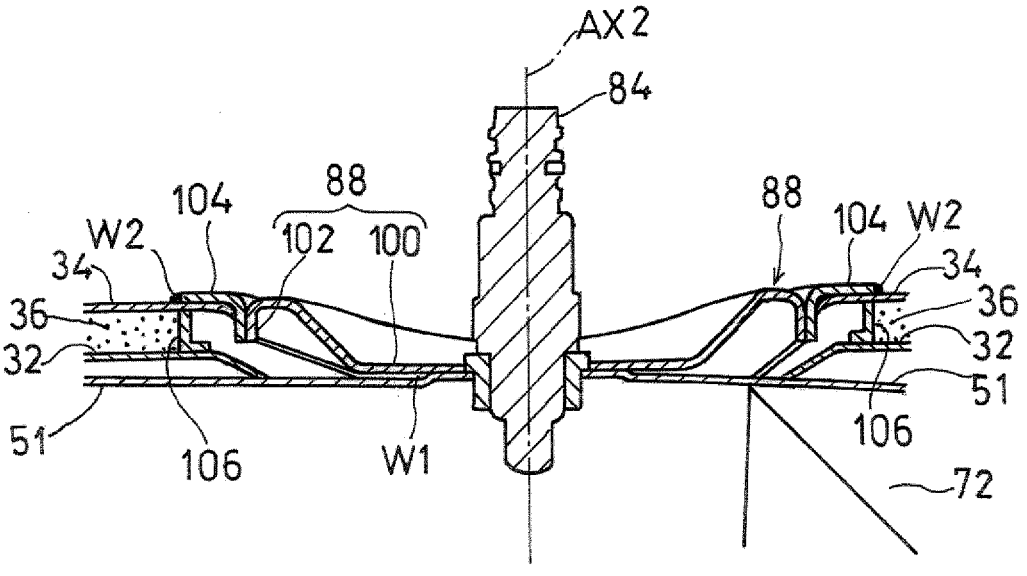
Fig. 7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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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