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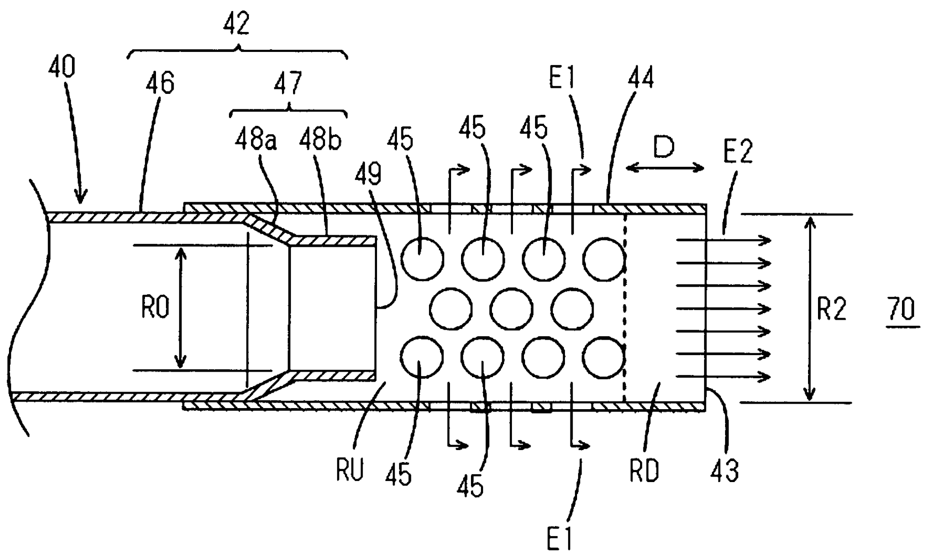
(54) **Exhaust system for a motorcycle and motorcycle comprising the same**

(57) An exhaust pipe (20) into which an exhaust gas from a single cylinder engine (50) flows is provided with a three way catalyst (90). The exhaust pipe includes a first pipe (42) inserted into a muffler (30) and a second pipe (44) extending toward the downstream side from the first pipe (42) within the muffler (30). A narrowed portion (47) having an inner diameter smaller than that of a cylindrical portion (46) of the first pipe (42) is provided in a downstream-end opening of the first pipe (42). The narrowed portion (47) is inserted into an upstream-end opening of the second pipe (44). A first expansion chamber (70) that integrally encloses the outer periphery and the downstream-end opening of the second pipe (44) is formed within the muffler (30). A plurality of holes (45) are formed in a distributed manner in a region, except a downstream region, of a peripheral surface of the second pipe (44). The length in the axial direction of the downstream region is not less than 1/3 times the inner diameter of the second pipe (44).

FIG. 5



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Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an exhaust system for a motorcycle and to a motorcycle including such an exhaust system.

Description of the Background Art

[0002] Conventionally, various mufflers have been developed in order to reduce exhaust sounds caused by discharges of exhaust gases from engines of automobiles (see JP 60-37287 B, for example).

[0003] The muffler disclosed in JP 60-37287 B has a perforated pipe and an external cylinder. The perforated pipe is inserted into the external cylinder. A resonant chamber is formed between an outer peripheral surface of the perforated pipe and an inner peripheral surface of the external cylinder. An expansion chamber is formed on the downstream side of the resonant chamber within the external cylinder. The resonant chamber and the expansion chamber are separated by a partition plate. An internal space of the perforated pipe communicates with the resonant chamber through holes of the perforated pipe. Furthermore, a downstream end of the perforated pipe is opened within the expansion chamber.

[0004] An end on the downstream side of the exhaust pipe is narrowed down, to form a small-diameter portion. The end of the exhaust pipe is fitted in the perforated pipe. The exhaust gas discharged from the exhaust pipe is introduced into the expansion chamber through the perforated pipe, and is further introduced into the atmosphere through a tail pipe. At this time, the exhaust sound is reduced by the function of the resonant chamber and the expansion chamber.

[0005] Meanwhile, mufflers are also provided in motorcycles. The mufflers used in the motorcycles are required to reduce exhaust sounds caused by discharges of high-pressure and high-temperature exhaust gases. Furthermore, the rotational speeds of engines of the motorcycles rise to not less than 8000 rpm. Therefore, the mufflers used in the motorcycles are required to bring out desired engine performances by adjusting the flows of the exhaust gases discharged from the engines.

[0006] In the case of multiple cylinder engines, a plurality of exhaust pipes communicate with one another, so that a pressure fluctuation in each of the exhaust pipes is absorbed by the other exhaust pipe. Therefore, the pressure fluctuation in each of the exhaust pipes is relatively small. In contrast, in the case of single cylinder engines, a pressure fluctuation in an exhaust pipe is great.

[0007] In recent years, motorcycles in which exhaust systems are provided with catalysts in order to clean up exhaust gases have been also developed. In this case, the temperatures of the exhaust gases rise by the catalysts. This causes the sound velocities to increase, causing high-frequency components of exhaust sounds to increase. As a result, metallic exhaust sounds including the high-frequency components are produced when the catalysts are employed for exhaust systems in the single cylinder engines.

[0008] Furthermore, mufflers that are thinner and shorter than those in automobiles are required from space limitations in the motorcycles.

[0009] When the structures of mufflers for automobiles are employed for the motorcycles having the catalysts, it is impossible to sufficiently reduce the high-frequency components of the exhaust sounds without increasing the sizes of the mufflers.

[0010] Particularly in motorcycles including the single cylinder engines, it is desired that the output performances of the engines are sufficiently brought out by small-sized mufflers while low exhaust sounds that are synchronized with burning of the engines are obtained.

SUMMARY OF THE INVENTION

[0011] An object of the present invention is to provide an exhaust system for a motorcycle allowing the output performance of an engine to be sufficiently brought out while high-frequency components of an exhaust sound is sufficiently reduced.

[0012] This object is achieved by an exhaust system according to claim 1.

(1) According to an aspect of the present invention, an exhaust system for a motorcycle includes an exhaust pipe, and a muffler that discharges the exhaust gas flowing out of the exhaust pipe to the outside, in which the exhaust pipe includes a first pipe having a downstream-end opening inserted into the muffler, and a second pipe having an upstream-end opening and a downstream-end opening and extending toward the downstream side from the first pipe within the muffler, a narrowed portion having an inner diameter smaller than that of the first pipe is provided in the downstream-end opening of the first pipe, and is inserted into the upstream-end opening of the second pipe, a first expansion chamber that integrally encloses the outer periphery and the downstream-end opening of the second pipe is formed within the muffler, and a plurality of holes are formed in a distributed manner in a region, except a region at a downstream end, of a peripheral surface of the second pipe, and the length in the axial direction of the region at the downstream end is not less than 1/3 times the inner diameter of the second pipe.

Embodiments of the invention concern a motorcycle including the exhaust system. In such a motorcycle, the exhaust gas from the single cylinder engine provided in the vehicle body flows into the exhaust pipe. At this time, the exhaust gas may be cleaned up by a catalyst while entering a high-temperature state. This causes the sound velocity to increase, causing the high-frequency components of the exhaust sound to increase.

The high-temperature exhaust gas flows out into the first expansion chamber in the muffler via the first pipe and the second pipe in the exhaust pipe. At this time, the exhaust gas is extruded into the second pipe while being compressed by the narrowed portion of the first pipe so that exhaust gas pressure (pressure of the exhaust gas) increases. Thisprevents an unburned mixed gas from going out in an overlap period of the engine. This results in improvements in torques generated by the engine in a low-speed area and a medium-speed area.

In this case, a part of the exhaust gas within the second pipe expands by flowing out into the first expansion chamber through the holes. Furthermore, the remaining exhaust gas within the second pipe expands by flowing out into the first expansion chamber from the downstream-end opening. In this case, the first expansion chamber integrally and continuously encloses the outer periphery and the downstream-end opening of the second pipe.

The plurality of holes are formed in the region, except the region at the downstream end, of the peripheral surface of the second pipe. The length in the axial direction of the region at the downstream end is set to not less than 1/3 times the inner diameter of the second pipe. Thus, the pressure fluctuation of the exhaust gas flowing out of the second pipe through the holes and the pressure fluctuation of the exhaust gas flowing out from the downstream-end opening of the second pipe respectively have high-frequency components of different phases. Therefore, the high-frequency components of different phases are canceled by each other. As a result, the high-frequency components of the exhaust sound is reduced.

Furthermore, the exhaust gas compressed by the narrowed portion of the first pipe expands step by step in the second pipe and the first expansion chamber. This causes a pressure wave that can be generated by rapid expansion of the exhaust gas to be relieved. This results in inhibition of the production of a sound caused by the pressure wave.

Furthermore, the first expansion chamber integrally encloses the outer periphery and the downstream-end opening of the second pipe within the muffler. Therefore, it is possible to ensure that the volume of the first expansion chamber serving as the same pressure space is sufficiently great. As a result, it is possible to sufficiently reduce the high-frequency components of the exhaust sound without increasing the length and the cross-sectional area of the muffler. These results show that the output performance of the single cylinder engine is sufficiently brought out while the high-frequency components of the exhaust sound is sufficiently reduced.

(2) The second pipe may be joined to the first pipe at a position on the upstream side of the narrowed portion.

In this case, the second pipe is reliably fixed to the first pipe in a cantilevered state without using a supporting member. This avoids the vibration and the swing of the second pipe being generated. This results in prevention of the production of a sound due to the vibration or the swing of the second pipe.

(3) The narrowed portion may include a tapered portion having an inner diameter that gradually decreases. In this case, it is possible to prevent the production of a flow noise due to the disturbance of the flow of the exhaust gas.

(4) A second expansion chamber may be further formed on the downstream side of the first expansion chamber within the muffler, the first expansion chamber and the second expansion chamber may be separated by a partition plate, and a connecting pipe may be provided to penetrate the partition plate.

In this case, the exhaust gas compressed by the narrowed portion of the first pipe expands step by step in the second pipe, the first expansion chamber, and the second expansion chamber. This causes a pressure wave that can be generated by rapid expansion of the exhaust gas to be effectively relieved. This results in sufficient inhibition of the production of a sound due to the pressure wave.

(5) The volume of the first expansion chamber may be greater than the volume of the second expansion chamber. In this case, the first expansion chamber integrally encloses the outer periphery and the downstream-end opening of the second pipe. Thus, it is possible to make the volume of the first expansion chamber greater than the volume of the second expansion chamber without increasing the length and the diameter of the muffler. Therefore, the high-frequency components of the exhaust sound can be effectively reduced in the first expansion chamber.

(6) In the exhaust pipe, a part of the first pipe may be held in the muffler, and the second pipe may not be held in the muffler.

[0013] In this case, no supporting member exists on the side of the outer periphery of the second pipe, so that the flow of the exhaust gas flowing out of the plurality of holes of the second pipe is not disturbed. This can prevent the production of a flow noise due to the disturbance of the flow of the exhaust gas.

[0014] According to the present invention, the output performance of the engine is sufficiently brought out while the high-frequency components of the exhaust sound is sufficiently reduced.

[0015] Other features, elements, characteristics, and advantages of the present invention will become more apparent from the following description of embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a side view of a motorcycle according to an embodiment of the present invention;
Fig. 2 is a perspective view of the appearance of an exhaust device as viewed from the top;
Fig. 3 is a perspective view of the appearance of the exhaust device as viewed from the side;
Fig. 4 is a cross-sectional view taken along a line IV - IV of a muffler shown in Fig. 2;
Fig. 5 is an enlarged sectional view of an exhaust pipe shown in Fig. 4;
Fig. 6 is a cross-sectional view of a muffler in a comparative example 1;
Fig. 7 is a diagram showing the respective results of measurement of the damping properties of a muffler in an inventive example and the muffler in the comparative example 1; and
Fig. 8 is a cross-sectional view of a muffler in a comparative example 2.

DESCRIPTION OF THE EMBODIMENTS

[0017] Referring to the drawings, embodiments of the present invention will be described while referring to the drawings. In the following description, the upstream side and the downstream side will be defined with the flow of an exhaust gas used as a basis.

(1) Configuration of motorcycle

[0018] Fig. 1 is a side view of a motorcycle according to an embodiment of the present invention.

[0019] A motorcycle 100 shown in Fig. 1 includes a vehicle body 80 composed of a vehicle body frame and a frame cover. A head pipe (not shown) is provided at the front of the vehicle body 80, and a handle 81 is provided at an upper end of the head pipe. A front fork 82 is attached to a lower end of the head pipe. In this state, the front fork 82 is rotatable within a predetermined angle range with the axis of the head pipe used as its center. A front wheel 83 is rotatably supported on a lower end of the front fork 82. A rear wheel 84 is rotatably supported at the rear of the vehicle body 80. A single cylinder engine 50 is provided at the center of the vehicle body 80. The rear wheel 84 is rotated by a rotating force of the engine 50.

[0020] An exhaust device 10 that introduces an exhaust gas to the outside is connected to a cylinder head 51 of the engine 50. The exhaust device 10 includes an exhaust pipe 20 and a muffler (silencer) 30. The exhaust pipe 20 extends backward from the cylinder head 51 of the engine 50. The muffler 30 extends toward the side of the rear wheel 84 from a downstream end of the exhaust pipe 20.

(2) Configuration of exhaust device 10

[0021] Fig. 2 is a perspective view of the appearance of the exhaust device 10 as viewed from the top. Fig. 3 is a perspective view of the appearance of the exhaust device 10 as viewed from the side.

[0022] An exhaust port connector 22 is provided at an upstream end of the exhaust pipe 20. An opening on the upstream side of the exhaust pipe 20 is connected to an exhaust port of the cylinder head 51 of the engine 50 shown in Fig. 1 by the exhaust port connector 22. The downstream end 24 of the exhaust pipe 20 is inserted into an upstream end (an inlet) of the muffler 30. The outer periphery at the upstream end of the muffler 30 is fastened by a mounting member 26 so that the muffler 30 is fixed to the exhaust pipe 20.

[0023] The downstream end 24 of the exhaust pipe 20 is connected to an upstream end of an exhaust pipe 40 within the muffler 30. A three way catalyst 90 is provided within the exhaust pipe 40. Note that the exhaust pipe 20 and the exhaust pipe 40 may be integrally formed. Alternatively, the exhaust pipe 20 and the exhaust pipe 40 may be connected to each other through another member. Covers 31a and 31b are attached to an outer peripheral surface of the muffler 30.

[0024] An exhaust gas generated by burning of an air-fuel mixture within the engine 50 shown in Fig. 1 is fed into the muffler 30 through the exhaust pipe 20. The exhaust gas is discharged into the atmosphere through the muffler 30. Thus, an exhaust path of the engine 50 includes the exhaust port of the cylinder head 51, the exhaust pipe 20, and the muffler 30 in the order from the upstream side to the downstream side.

[0025] The muffler 30 has a muffling function for reducing an exhaust sound before discharging the exhaust gas into the atmosphere. In the present embodiment, the inside of the muffler 30 has a structure of a multistage expansion type, described later. That is, the inside of the muffler 30 is partitioned into a plurality of expansion chambers, so that the exhaust gas expands by passing through the plurality of expansion chambers. This causes the exhaust gas to be depressurized.

(3) Internal structure of muffler 30

[0026] The internal structure of the muffler 30 will be then described while referring to Fig. 4. Fig. 4 is a cross-sectional view taken along a line IV - IV of the muffler 30 shown in Fig. 2. Fig. 5 is an enlarged sectional view of the exhaust pipe 40 shown in Fig. 4.

[0027] As shown in Fig. 4, the muffler 30 includes a conical head 32, a hollow cylindrical body 34, and a bowl-shaped tail 37. The head 32 is fitted in an opening on the upstream side of the body 34. The tail 37 is fitted in an opening on the downstream side of the body 34.

[0028] Partition plates 36 and 38 are arranged with predetermined spacing in the order from the upstream side at positions close to a downstream end of the body 34.

Thus, an internal space of the muffler 30 is partitioned into a first expansion chamber 70, a second expansion chamber 72, and a third expansion chamber 74. The first expansion chamber 70, the second expansion chamber 72, and the third expansion chamber 74 line up in the order from the upstream side to the downstream side in the longitudinal direction of the muffler 30.

[0029] A connecting pipe 62 penetrates the partition plate 36, a connecting pipe 64 penetrates the partition plate 38, and a tail pipe 66 penetrates the tail 37.

[0030] The exhaust pipe 40 is inserted into the head 32. A downstream portion of the exhaust pipe 40 extends into the first expansion chamber 70. The exhaust gas is introduced into the first expansion chamber 70 through the exhaust pipe 40.

[0031] The exhaust pipe 40 includes a first pipe 42 on the upstream side and a cylindrical second pipe 44 on the downstream side. The first pipe 42 has a cylindrical portion 46 on the upstream side and a narrowed portion 47 on the downstream side. The narrowed portion 47 has a tapered portion 48a and a small-diameter portion 48b. The small-diameter portion 48b has an outer diameter and an inner diameter respectively smaller than the outer diameter and the inner diameter of the cylindrical portion 46. The outer diameter and the inner diameter of the tapered portion 48a gradually decrease from an outer diameter and an inner diameter that are the same as those of the cylindrical portion 46 toward an outer diameter and an inner diameter that are the same as the small-diameter portion 48b. Thus, the cross-sectional area of a flow path of the narrowed portion 47 gradually decreases from the upstream side to the downstream side.

[0032] The inner diameter R2 of the second pipe 44 is equal to the outer diameter of the cylindrical portion 46 of the first pipe 42. The narrowed portion 47 of the first pipe 42 is inserted into an upstream-end opening of the first pipe 42 such that an upstream end of the second pipe 44 is overlapped with the cylindrical portion 46 at a position on the upstream side of the narrowed portion 47 of the first pipe 42. In this state, an outer peripheral surface of the cylindrical portion 46 of the first pipe 42 and an inner peripheral surface of the second pipe 44 are welded so that the second pipe 44 is joined to the cylindrical portion 46. Thus, the second pipe 44 is held in the first pipe 42 in a cantilevered state. Furthermore, a cylindrical clearance is formed between the inner peripheral surface of the second pipe 44 and the narrowed portion 47. The tapered portion 48a is opened within the second pipe 44.

[0033] The first pipe 42 is attached to an inner surface of the head 32 through a supporting stay 35 so as to be positioned at the center of the head 32 and the body 34.

[0034] The inner diameter R0 of the small-diameter portion 48b of the narrowed portion 47 is smaller than the inner diameter R1 of the cylindrical portion 46 ($R0<R1$). The inner diameter R2 of the second pipe 44 is larger than the inner diameter R0 of the small-diameter portion 48b of the narrowed portion 47 and is smaller than the inner diameter R3 of the first expansion chamber 70 ($R0<R2<R3$). This enables a pressure fluctuation created by rapid expansion of the exhaust gas flowing out of the first pipe 42 into the first expansion chamber 70 to be relieved.

[0035] In this case, it is preferable that the inner diameter R2 of the second pipe 44 is not too close to the inner diameter R3 of the expansion chamber 70 and is not too close to the inner diameter R0 of the small-diameter portion 48b. This enables a pressure wave caused by the rapid expansion of the exhaust gas to be sufficiently relieved by the second pipe 44.

[0036] It is preferable that the inner diameter R2 of the second pipe 44 is approximately equal to the inner diameter R1 of the cylindrical portion 46 of the first pipe 42. In the present embodiment, the inner diameter R2 of the second pipe 44 is equal to the outer diameter of the cylindrical portion 46 of the first pipe 42. Therefore, the inner diameter R2 of the second pipe 44 is approximately equal to the inner diameter R1 of the cylindrical portion 46 of the first pipe 42. This enables the pressure wave to be effectively relieved.

[0037] Note that a length L from a downstream-end opening 49 of the narrowed portion 47 to a downstream-end opening 43 of the second pipe 44 is not particularly limited and is determined such that a low-frequency component of the exhaust sound does not disappear and the strength of the second pipe 44 held in a cantilevered state is ensured.

[0038] As shown in Fig. 5, the second pipe 44 includes an upstream region RU where a plurality of holes 45 are provided and a downstream region RD where no holes are substantially provided in the order toward the downstream side. The plurality of holes 45 are equally spaced in the upstream region RU. The plurality of holes 45 are punching holes, for example. The plurality of holes 45 penetrate the second pipe 44 from its outer peripheral surface to its inner peripheral surface. In the present embodiment, the shape of each of the holes 45 is circular.

[0039] The downstream region RD has a length D toward the upstream side from the downstream-end opening 43 of the second pipe 44. The length D of the downstream region RD is not less than 1/3 times the inner diameter R2 of the second pipe 44.

[0040] The downstream region RD may be provided with one or more holes so as to have an opening ratio that is not more than one third of the opening ratio of the upstream region RU. The opening ratio of the upstream region RU means the ratio of the sum of the open areas of the plurality of holes 45 to the area of the upstream region RU. The opening ratio of the downstream region RD means the ratio of the sum of the open areas of the one or more holes to the area of the downstream region RD. In this case, the one or more holes provided in the downstream region RD hardly affect the effect of reducing a high-frequency components, described later. Therefore, the fact that the downstream region RD is provided with the one or more holes so as to have the opening ratio that is not more than one third the opening ratio of the upstream region RU means that no holes are substantially provided in the downstream region RD.

[0041] Although the ratio of the sum of the open areas of the plurality of holes 45 to the cross-sectional area of the flow path of the second pipe 44 (hereinafter referred to as an area ratio of the plurality of holes 45) is not particularly limited, it is preferable that the area ratio of the plurality of holes 45 is not less than 0.5 nor more than 2.0, for example, approximately 1.0.

[0042] Note that the inner diameter of each of the holes 45 and the pitch between the holes 45 (the distance between the centers of the adjacent holes 45) can be adjusted as needed such that the above-mentioned sound reducing effect can be satisfactorily attained. In this case, the inner diameter of each of the holes 45 and the pitch between the holes 45 can be selected so as to efficiently obtain the sound reducing effect while restraining a pressure loss.

(4) Operation of exhaust device 10

[0043] The operation of the exhaust device 10 according to the present embodiment will be then described.

[0044] An exhaust gas from the exhaust port of the engine 50 shown in Fig. 1 is introduced into the exhaust pipe 40 through the exhaust pipe 20 shown in Figs. 2 and 3. At this time, the exhaust gas is cleaned up by the three way catalyst 90 while entering a high-temperature state. This causes the sound velocity to increase, causing a high-frequency components of an exhaust sound to increase.

[0045] The high-temperature exhaust gas flows out into the first expansion chamber 70 in the muffler 30 via the first pipe 42 and the second pipe 44 in the exhaust pipe 40. At this time, the exhaust gas is extruded into the second pipe 44 while being compressed by the narrowed portion 47 of the first pipe 42 so that exhaust gas pressure (pressure of the exhaust gas) increases. This prevents an unburned mixed gas from going out in an overlap period (a period during which both a suction valve and an exhaust valve are opened) of the engine 50. This results in improvements in torques generated by the engine 50 in a low-speed area and a medium-speed area.

[0046] The exhaust gas compressed by the narrowed portion 47 expands by flowing out into the second pipe 44. As shown in Fig. 5, an exhaust gas E1 that is a part of the exhaust gas within the second pipe 44 expands by flowing out into the first expansion chamber 70 through the holes 45. Furthermore, the remaining exhaust gas E2 expands by flowing out into the first expansion chamber 70 from the downstream-end opening 43 of the second pipe 44. In this case, the first expansion chamber 70 integrally and continuously encloses the outer periphery and the downstream-end opening 43 of the second pipe 44.

[0047] The holes 45 are formed in the upstream region RU, except in the downstream region RD, as described above. Therefore, the pressure fluctuation of the exhaust gas E1 flowing out of the second pipe 44 through the holes 45 and the pressure fluctuation of the exhaust gas E2 flowing out from the downstream-end opening 43 of the second pipe 44 respectively have high-frequency components of different phases. Thus, the high-frequency components of the pressure fluctuation of the exhaust gas E1 and the high-frequency components of the pressure fluctuation of the exhaust gas E2 are canceled by each other within the same pressure space. The results of considerations given by the inventors of the present invention show that the high-frequency components are effectively canceled by each other when the length D of the downstream region RD is not less than 1/3 times the inner diameter R2 of the second pipe 44. This causes the high-frequency components of the exhaust sound to be reduced.

[0048] Furthermore, the exhaust gas compressed by the narrowed portion 47 of the first pipe 42 expands step by step in the second pipe 44 and the first expansion chamber 70. This causes a pressure wave that can be generated by rapid expansion of the exhaust gas to be relieved. This results in inhibition of the production of a sound due to the pressure wave (particularly a metallic sound including the high-frequency components).

[0049] The exhaust gas within the first expansion chamber 70 expands by flowing out into the second expansion chamber 72 through the connecting pipe 62. The exhaust gas within the second expansion chamber 72 expands by flowing out into the third expansion chamber 74 through the connecting pipe 64. The exhaust gas within the third expansion chamber 74 is discharged to the outside through the tail pipe 66 and is released to the atmosphere.

[0050] If the distance between the downstream-end opening 43 of the second pipe 44 and the upstream-end opening of the connecting pipe 62 is too small, a muffling effect is reduced. If the distance between the downstream-end opening 43 of the second pipe 44 and the partition plate 36 is too small, the torque generated by the engine 50 is reduced. Therefore, the length D of the downstream region RD is preferably not more than three times and more preferably not more than two times the inner diameter R2 of the second pipe 44.

(5) Effects of preferred embodiment

[0051] In the motorcycle 100 according to the present embodiment, the exhaust gas introduced into the exhaust pipe 40 from the single cylinder engine 50 through the exhaust pipe 20 is compressed by the narrowed portion 47 of the first pipe 42. This prevents the unburned mixed gas from going out from the engine 50. This results in improvements in torques generated by the engine 50 in the low-speed area and the medium-speed.

[0052] Furthermore, the exhaust gas compressed by the narrowed portion 47 of the first pipe 42 expands step by step in the second pipe 44, the first expansion chamber 70, the second expansion chamber 72, and the third expansion chamber 74 so that the pressure of the exhaust gas decreases to the atmospheric pressure step by step. This causes the exhaust sound to be reduced.

[0053] In this case, the exhaust gas E1 within the second pipe 4 flows out into the first expansion chamber 70 through the holes 45, and the remaining exhaust gas E2 flows out into the first expansion chamber 70 from the downstream-end opening 43. Thus, the high-frequency components of the pressure fluctuation of the exhaust gas E1 and the high-frequency components of the pressure fluctuation of the exhaust gas E2 are canceled by each other within the first expansion chamber 70 serving as the same pressure space. This causes the high-frequency components of the pressure fluctuation increased by the three way catalyst 90 to be reduced. Therefore, the high-frequency components of the exhaust sound is sufficiently reduced. As a result, it is possible to obtain an intermittent low exhaust sound that is synchronized with burning of the single cylinder engine 50 while inhibiting the metallic sound including the high-frequency components from being produced.

[0054] Furthermore, the second pipe 44 is fixed to the first pipe 42 in a cantilevered state at its upstream end. Thus, no supporting member exists on the side of the outer periphery of the second pipe 44, and the first expansion chamber 70 integrally and continuously encloses the outer peripheral surface and the downstream-end opening 43 of the second pipe 44. Therefore, it is possible to ensure that the volume of the first expansion chamber 70 serving as the same pressure space is sufficiently great. As a result, it is possible to sufficiently reduce the high-frequency components of the exhaust sound without increasing the length and the diameter of the muffler 30. Furthermore, this can prevent the production of a flow noise due to the disturbance of the flow of the exhaust gas.

[0055] Since the second pipe 44 is connected to the first pipe 42 at a position on the upstream side of the narrowed portion 47, the second pipe 44 is stably fixed to the outer peripheral surface of the first pipe 42 with high strength. This avoids the vibration and the swing of the second pipe 44 being produced. This results in prevention of the production of a sound having a natural frequency of the vibration or the swing of the second pipe 44 and a continuous sound caused by the vibration or the swing of the second pipe 44.

(6) Other Embodiments

[0056] Although the narrowed portion 47 has the tapered portion 48a and the small-diameter portion 48b in the above-mentioned embodiment, the narrowed portion 47 may have a step structure unless the flow of the exhaust gas is disturbed. In such a case, exhaust pressure is also increased by the narrowed portion 47.

[0057] Although the shape of the plurality of holes 45 is circular in the above-mentioned embodiment, the present invention is not limited to the same. For example, the shape of the plurality of holes 45 may be elliptical or polygonal.

[0058] Furthermore, although the plurality of holes 45 are equally spaced in the upstream region RU, except in the downstream region RD, the plurality of holes 45 may be randomly arranged.

[0059] Although the first pipe 42 and the second pipe 44 respectively have circular cross sections in the above-mentioned embodiment, the present invention is not limited to the same. For example, the first pipe 42 and the second pipe 44 may respectively have elliptical cross sections. In this case, the length of the long axis of an ellipse is taken as an inner diameter. Therefore, the length D of the downstream region RD of the second pipe 44 is set to not less than 1/3 times the length of the long axis of the ellipse and preferably not more than three times and more preferably not more than two times the inner diameter R2 of the second pipe 44. Furthermore, the first pipe 42 and the second pipe 44 may respectively have polygonal cross sections. In this case, the length of the longest diagonal line of a polygon is taken as an inner diameter. Therefore, the length D of the downstream region RD of the second pipe 44 is set to not less than 1/3 times the length of the longest diagonal line of the polygon and preferably not more than three times and more preferably not more than two times the inner diameter R2 of the second pipe 44.

[0060] Although the three way catalyst 90 is used in the above-mentioned embodiment, the present invention is not limited to the same. The three way catalyst 90 may be replaced with an oxidation catalyst or a reduction catalyst, for example.

(7) Examples

[0061] The effects of respectively reducing high-frequency components of exhaust sounds by mufflers in an inventive example and comparative examples 1 and 2 were examined. In the inventive example, the muffler 30 shown in Fig. 4 was used.

[0062] Fig. 6 is a cross-sectional view of the muffler in the comparative example 1. The muffler 30a shown in Fig. 6 differs from the muffler 30 shown in Fig. 4 in that the muffler 30a shown in Fig. 6 does not have the second pipe 44. The configuration of the other portions of the muffler 30a shown in Fig. 6 is the same as the configuration of the muffler 30 shown in Fig. 4.

[0063] In the muffler 30 in the inventive example and the muffler 30a in the comparative example 1, the inner diameter R0 of the narrowed portion 47 is 16.1 mm, and the inner diameter R1 of the first pipe 42 is 23.6 mm. Furthermore, the inner diameter and the length of the connecting pipe 62 are respectively 28.6 mm and 50 mm, the inner diameter and the length of the connecting pipe 64 are respectively 22.2 mm and 50 mm, and the inner diameter and the length of the tail pipe 66 are respectively 22.2 mm and 30 mm.

[0064] In the muffler 30 in the inventive example, the inner diameter R2 of the second pipe 44 is 27.4 mm, the inner diameter of the holes 45 is 5 mm, and the pitch between the holes 45 is 7.5 mm. The diameter of the holes 45 is 5 mm, and the length L from the downstream-end opening 49 of the narrowed portion 47 to the downstream-end opening 43 of the second pipe 44 is 42 mm. The length D of the downstream region RD is 9.5 mm.

[0065] The respective damping properties of the exhaust sounds by the muffler 30 in the inventive example and the muffler 30a in the comparative example 1 were measured.

[0066] Fig. 7 is a diagram showing the respective results of the measurement of the damping properties of the muffler 30 in the inventive example and the muffler 30a in the comparative example 1. In Fig. 7, the horizontal axis represents a frequency (Hz), and the vertical axis represents a sound pressure level (dB). In the same frequency, the lower the sound pressure level is, the lower a noise value is.

[0067] In Fig. 7, the damping properties of the muffler 30 in the inventive example is indicated by a thick solid line L0, and the damping properties of the muffler 30s in the comparative example 1 is indicated by a thin solid line L1.

[0068] In regions indicated by arrows B1 and B2, the sound pressure levels of high-frequency components in the muffler 30 in the inventive example were made sufficiently lower than the sound pressure levels thereof in the muffler 30a in the comparative example 1. The respective damping properties of a low-frequency component of less than 2000 Hz in the muffler 30 in the inventive example and the muffler 30a in the comparative example 1 were substantially equal.

[0069] Thus, the use of the muffler 30 in the inventive example caused the sound pressure levels of high-frequency components of not less than 2000 Hz to be sufficiently reduced. Therefore, it was found that the use of the muffler 30 in the inventive example could inhibit the production of a metallic exhaust sound including the high-frequency components.

[0070] Fig. 8 is a cross-sectional view of the muffler in the comparative example 2. The muffler 30b shown in Fig. 8 differs from the muffler 30 shown in Fig. 4 in the following points. In the muffler 30b shown in Fig. 8, the plurality of holes 45 are equally formed in the whole of the second pipe 44. The configuration of the other portions of the muffler 30a shown in Fig. 8 is the same as the configuration of the muffler 30 shown in Fig. 4.

[0071] Exhaust sounds in cases where the muffler 30 in the inventive example and the muffler 30a in the comparative example 2 were used were compared. The use of the muffler 30 in the inventive example sufficiently inhibited the production of a metallic sound including the high-frequency components. On the other hand, the use of the muffler 30b in the comparative example 2 caused a metallic sound including the high-frequency components to be produced.

[0072] The results showed that the formation of the plurality of holes 45 in the upstream region RU, except in the downstream region RD, could inhibit the production of the metallic sound including the high-frequency components.

(8) Correspondences between constituent elements in claims and parts in the embodiments

[0073] In the following paragraphs, non-limiting examples of correspondences between various elements recited in the claims below and those described above with respect to various embodiments of the present invention are explained.

[0074] In the embodiments described above, the vehicle body 80 is an example of a vehicle body, the engine 50 is an example of an engine, the exhaust pipes 20 and 40 are examples of an exhaust pipe, the three way catalyst 90 is an example of a catalyst, the muffler 30 is an example of a muffler, the first pipe 42 is an example of a first pipe, the second pipe 44 is an example of a second pipe, the narrowed portion 47 is an example of a narrowed portion, the first expansion chamber 70 is an example of a first expansion chamber, and the holes 45 is an example of a hole.

[0075] Furthermore, the second expansion chamber 72 is an example of a second expansion chamber, the partition plate 36 is an example of a partition plate, the connecting pipe 36 is an example of a connecting pipe, and the tapered portion 48a is an example of a tapered portion.

[0076] As each of various elements recited in the claims, various other elements having configurations or functions described in the claims can be also used.

[0077] While embodiments of the present invention have been described above on the basis of motorcycles having a catalyst, it is noted the inventive exhaust system may also be used in motorcycles having no catalyst.

Claims

1. An exhaust system for a motorcycle comprising:

an exhaust pipe; and
a muffler that discharges the exhaust gas flowing out of the exhaust pipe to the outside,
wherein the exhaust pipe includes
a first pipe having a downstream-end opening inserted into the muffler, and
a second pipe having an upstream-end opening and a downstream-end opening and extending toward the downstream side from the first pipe within the muffler,

wherein a narrowed portion having an inner diameter smaller than that of the first pipe is provided in the downstream-end opening of the first pipe, and is in-

serted into the upstream-end opening of the second pipe,
wherein a first expansion chamber that integrally encloses the outer periphery and the downstream-end opening of the second pipe is formed within the muffler, and
wherein a plurality of holes are formed in a distributed manner in a region, except a region at a downstream end, of a peripheral surface of the second pipe, and the length in the axial direction of the region at the downstream end is not less than 1/3 times the inner diameter of the second pipe.

2. The exhaust system according to claim 1, wherein the second pipe is joined to the first pipe at a position on the upstream side of the narrowed portion.

3. The exhaust system according to claim 1 or 2, wherein the narrowed portion includes a tapered portion having an inner diameter that gradually decreases.

4. The exhaust system according to any one of claims 1 to 3, wherein a second expansion chamber is further formed on the downstream side of the first expansion chamber within the muffler, the first expansion chamber and the second expansion chamber are separated by a partition plate, and a connecting pipe is provided to penetrate the partition plate.

5. The exhaust system according to claim 4, wherein the volume of the first expansion chamber is greater than the volume of the second expansion chamber.

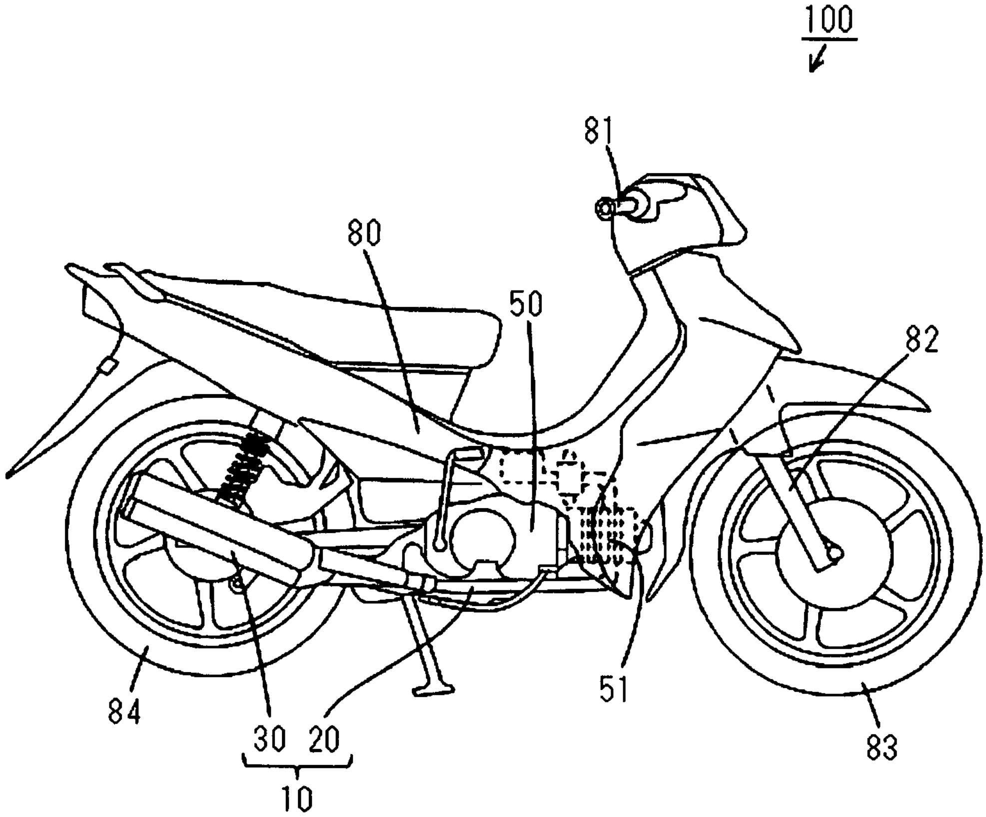
6. The exhaust system according to any one of claims 1 to 5, wherein in the exhaust pipe, a part of the first pipe is held in the muffler, and the second pipe is not held in the muffler.

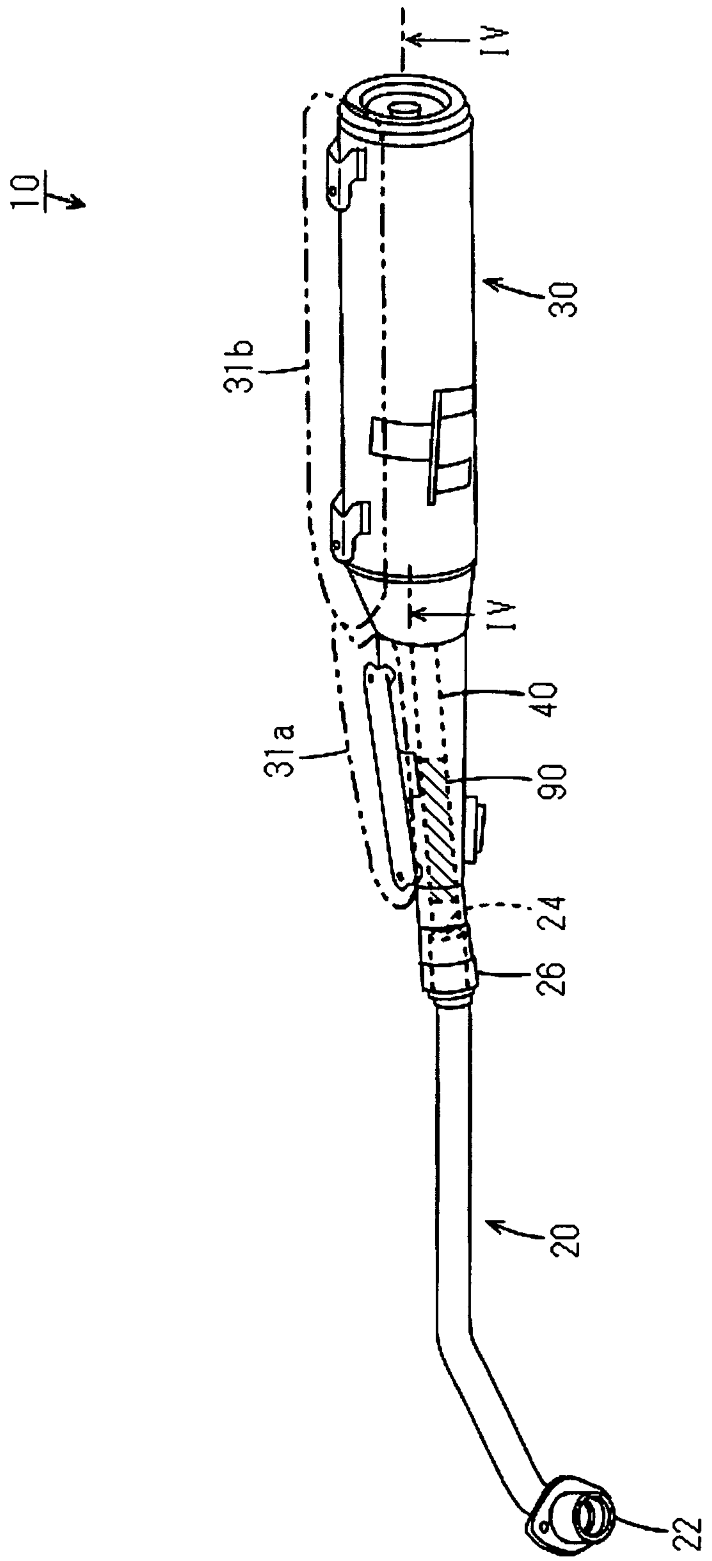
7. A motorcycle, comprising:

    a vehicle body;
    a single cylinder engine provided in the vehicle body;
    an exhaust pipe into which an exhaust gas from the engine flows;
    an exhaust system according to any one of claims 1 to 6, wherein an exhaust gas from the engine flows into the exhaust pipe.

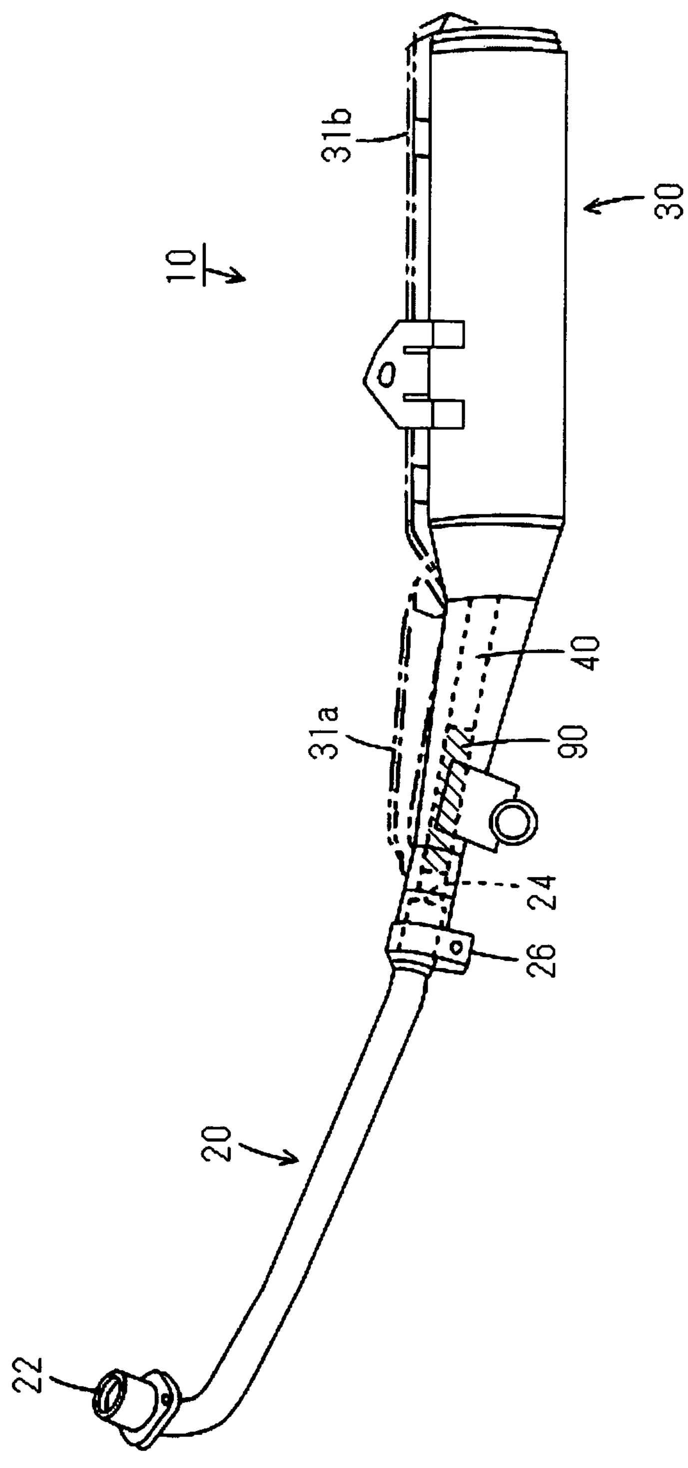
8. The motorcycle of claim 7, further comprising a catalyst provided in the exhaust pipe.

F I G. 1





F I G. 2



F I G. 3

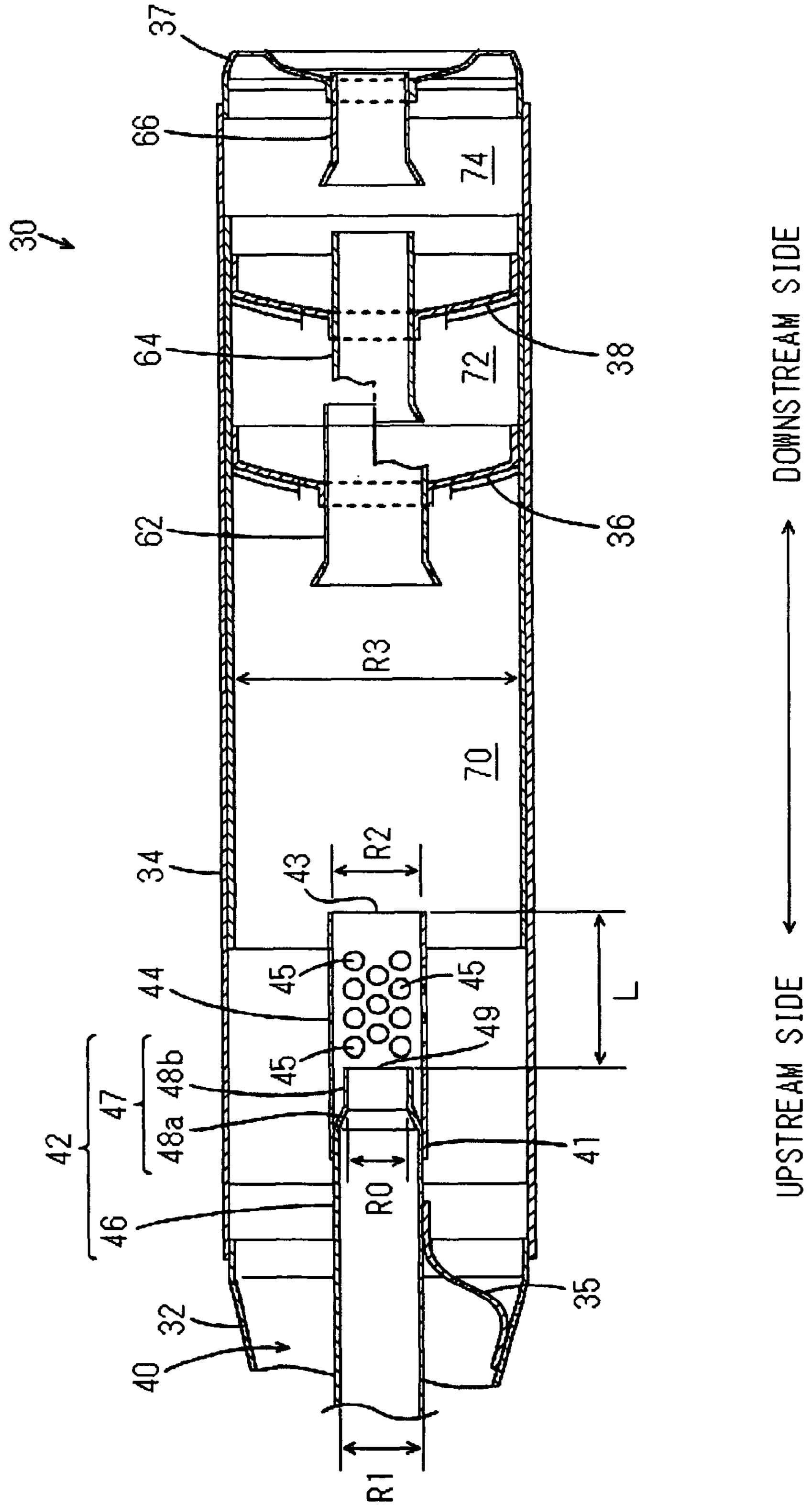
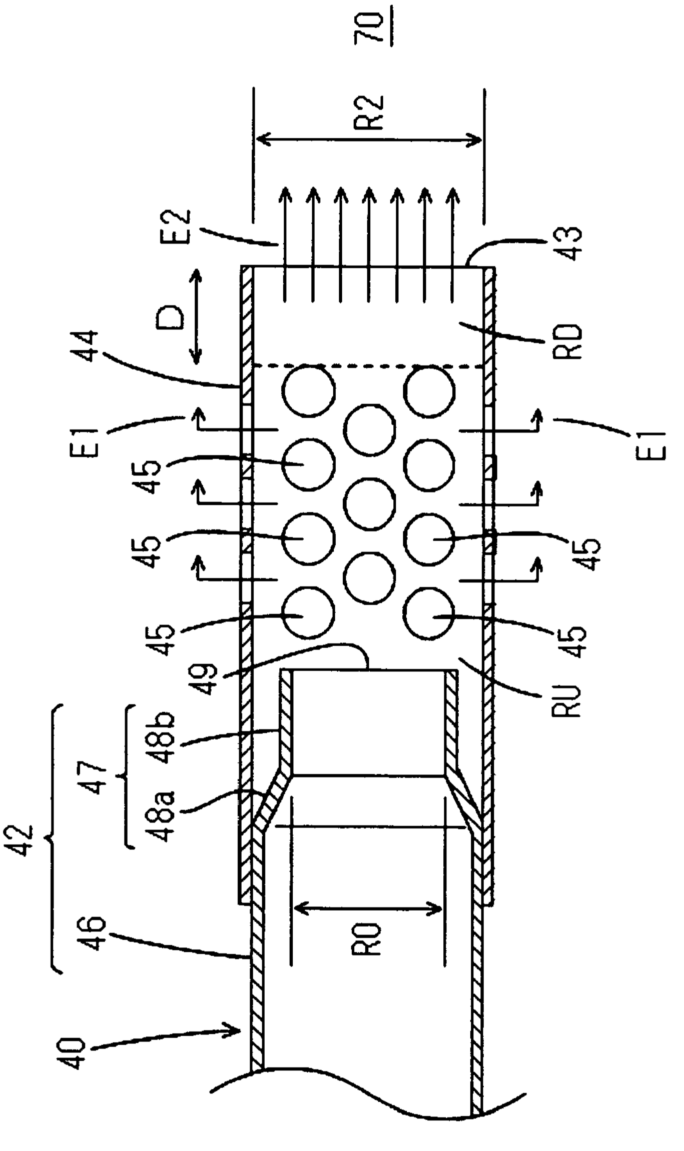
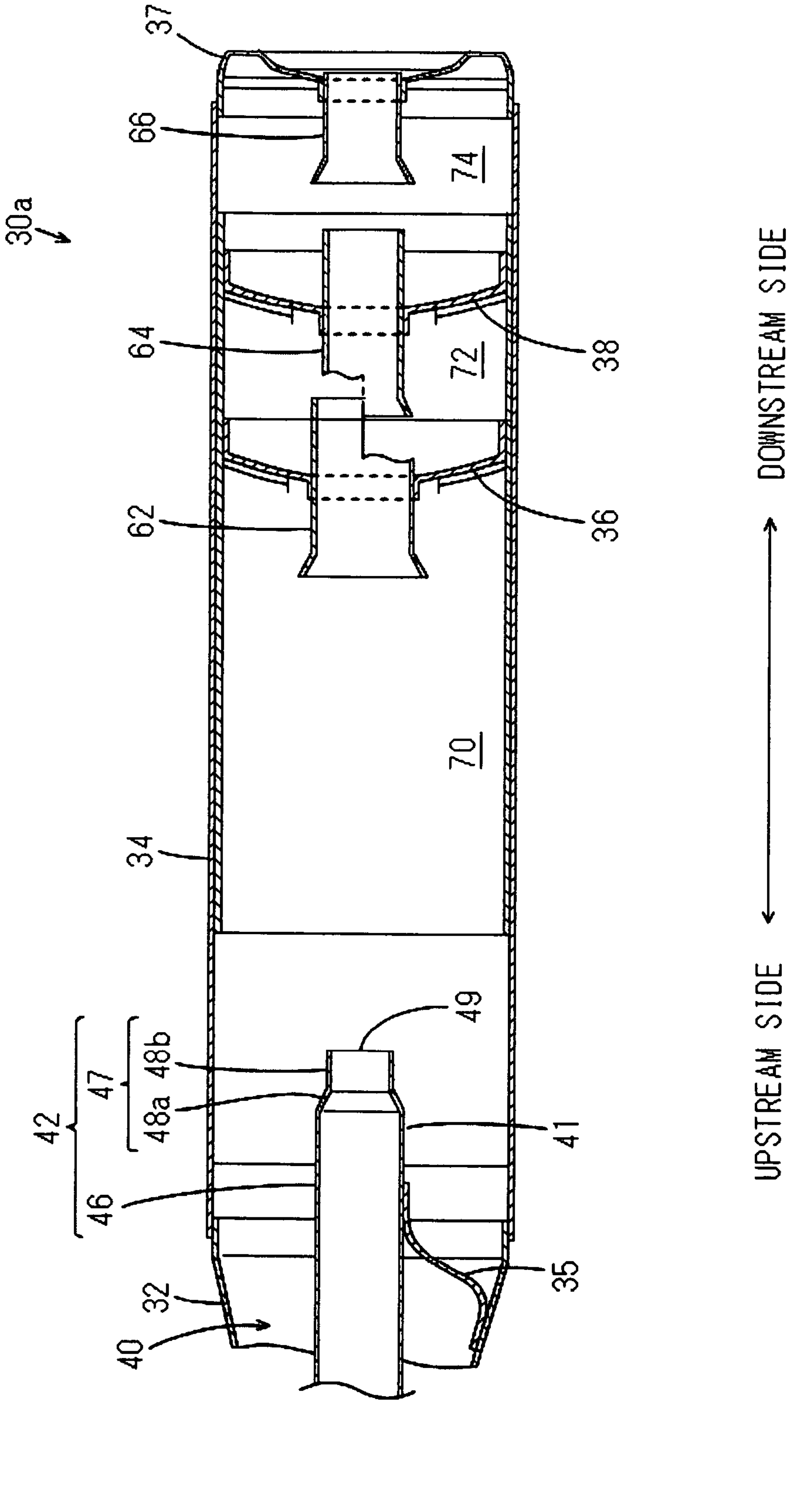

30
37
66
74
64
72
38
62
36
R3
70
34
43
R2
44
45
45
45
L
49
42
47
48b
48a
41
R0
46
35
32
40
R1
DOWNSTREAM SIDE
UPSTREAM SIDE

FIG. 4



F I G. 5


30a
37
66
74
64
72
38
62
36
70
34
49
48b
47
48a
42
41
46
32
35
40
UPSTREAM SIDE
DOWNSTREAM SIDE

F I G. 6

F I G. 7

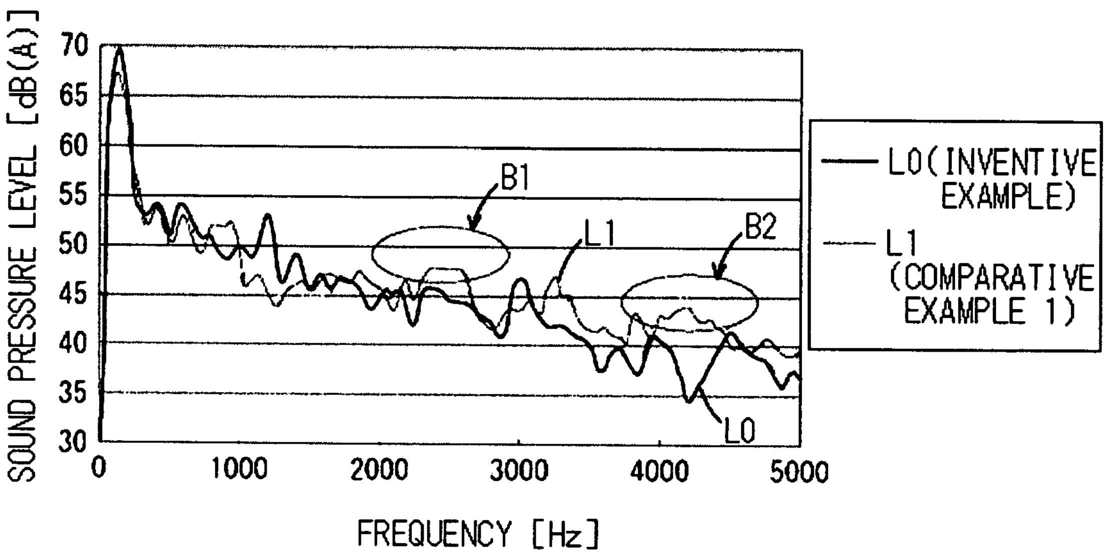
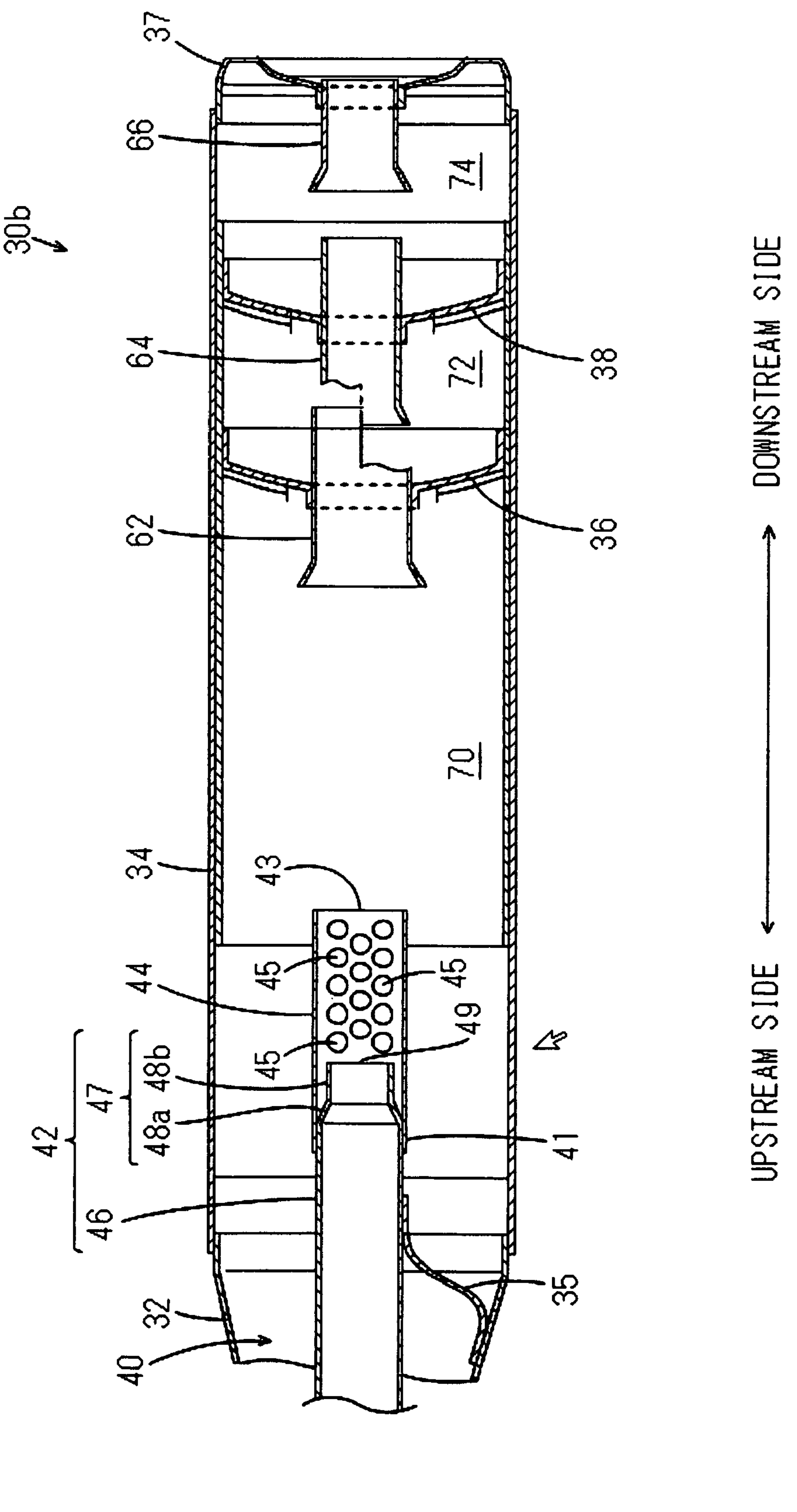

SOUND PRESSURE LEVEL [dB(A)]
70
65
60
55
50
45
40
35
30
0
1000
2000
3000
4000
5000
FREQUENCY [Hz]
B1
L1
B2
L0
L0(INVENTIVE EXAMPLE)
L1 (COMPARATIVE EXAMPLE 1)

FIG. 8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42
41
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35
32
40
DOWNSTREAM SIDE
UPSTREAM SIDE

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EUROPEAN SEARCH REPORT

Application Number
EP 09 00 8321

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 10 2006 056414 A1 (HARLEY DAVIDSON MOTOR CO INC [US]) 5 July 2007 (2007-07-05) * paragraph [0017] - paragraph [0019]; figure 2 * -----	1-3,6,7 4,5,8	INV. F01N1/08 F01N3/28
Y	US 2006/000205 A1 (BOZMOSKI ALEXANDER J [US] ET AL) 5 January 2006 (2006-01-05) * paragraph [0019] * * paragraph [0029]; figures 1,2,5,6 * -----	4,5,8	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01N

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 October 2009	Zebst, Marc

2

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102006056414 A1	05-07-2007	JP 2007182878 A	19-07-2007
		US 2007151798 A1	05-07-2007
US 2006000205 A1	05-01-2006	DE 102005029279 A1	19-01-2006
		JP 2006017124 A	19-01-2006
		US 2007256673 A1	08-11-2007

EPO FORM P0459

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Patent documents cited in the description

- JP 60037287 B **[0002] [0003]**