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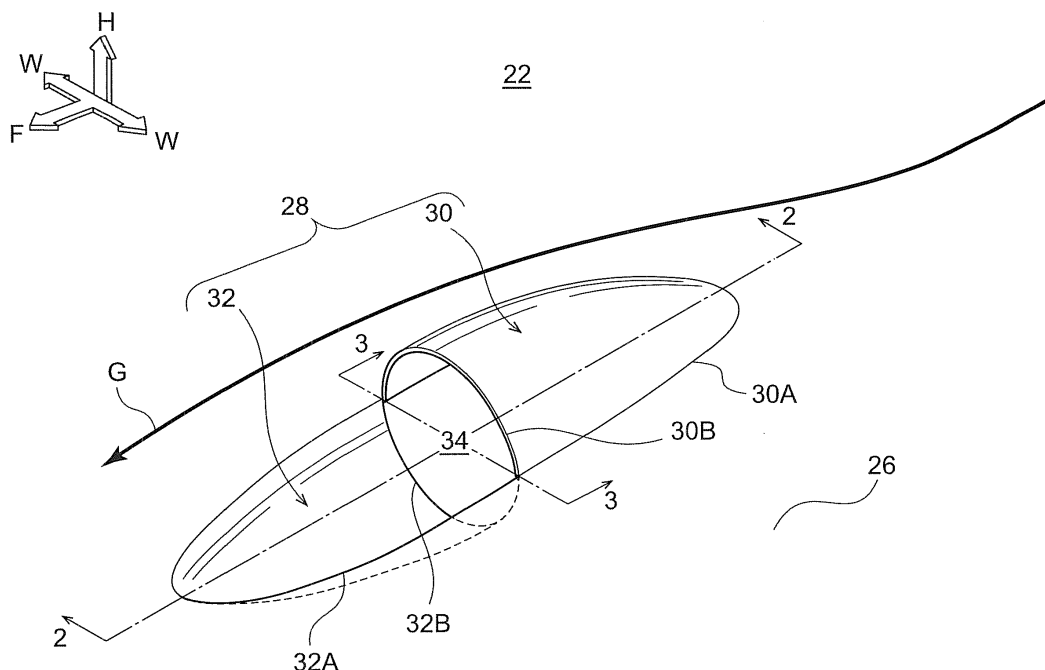
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(54) **MUFFLER**

(57) Muffler (10) includes inner pipe (14) inserted into outer shell (12) and through which exhaust gas flows; and communication portions formed in a peripheral wall (26) of the inner pipe (14) and including holes that communicate a gas flow path of the inner pipe with a muffling chamber (24), each of the communication portions including: inside deformation portion formed by deforming a portion of the peripheral wall toward the pipe inside, and having a downstream side end portion separated

from the peripheral wall; and outside deformation portion formed by deforming a portion of the peripheral wall adjacent to the downstream side of the inside deformation portion toward the pipe outside, and having an upstream side end portion separated from the peripheral wall, and wherein the hole is formed by the downstream side end portion of the inside deformation portion and the upstream side end portion of the outside deformation portion.

FIG.1**EP 3 073 076 A1**

Description

BACKGROUND

Technical Field

[0001] The present disclosure relates to a muffler.

Related Art

[0002] Conventional mufflers are known in which small holes are formed in a peripheral wall of an inner pipe inserted into the interior of an outer shell, and an exhaust gas flow path in an interior of the inner pipe is placed in communication with a muffling chamber at an exterior of the inner pipe (for example, see Japanese Patent Application Laid-open (JP-A) No. 2002-47910).

[0003] However, in such conventional mufflers, fine particles, such as soot contained in the exhaust gas, are liable to collect at the edges of the small holes, and the small holes may be closed off by the fine particles. Such conventional mufflers are therefore liable to exhibit decreased exhaust muffling performance due to aging.

[0004] Hence, it is conceivable that a structure in which fine particles do not easily block the small holes could be applied; however, it would be undesirable for such structures to cause a large increase in resistance to ventilation of the exhaust gas.

SUMMARY

[0005] In consideration of the above circumstances, the present disclosure provides a muffler that makes it difficult for fine particles such as soot to block small holes placing the interior and exterior of an inner pipe in communication with each other, without a large attendant increase in ventilation resistance.

[0006] A muffler of one aspect of the present disclosure includes an inner pipe that is inserted into an interior of an outer shell, and a plurality of communication portions that are formed in a peripheral wall of the inner pipe, and that include holes that place an exhaust gas flow path in an interior of the inner pipe in communication with a muffling chamber at an exterior of the inner pipe. Each of the communication portions includes an inside deformation portion that is formed by deforming a portion of the peripheral wall toward the interior of the inner pipe and that has a gas flow downstream side end portion separated from the peripheral wall, and an outside deformation portion that is formed by deforming a portion of the peripheral wall adjacent to the gas flow downstream side of the inside deformation portion toward the exterior of the inner pipe and that has a gas flow upstream side end portion separated from the peripheral wall. The hole is formed by the downstream side end portion of the inside deformation portion and the upstream side end portion of the outside deformation portion.

[0007] In the muffler of the present aspect, the plural

communication portions are formed in the peripheral wall of the inner pipe. The communication portions include the holes that place the exhaust gas flow path in the interior of the inner pipe in communication with the muffling chamber at the exterior of the inner pipe. Namely, the exhaust gas flow path in the interior of the inner pipe is placed in communication with the muffling chamber at the exterior of the inner pipe by the holes in the communication portions. Accordingly, sound waves caused by exhaust gas flowing through the exhaust gas pathway in the interior of the inner pipe pass through the holes, and are attenuated in the muffling chamber at the exterior of the inner pipe.

[0008] Moreover, the communication portions each include the inside deformation portion and the outside deformation portion. The inside deformation portion is formed by deforming a portion of the peripheral wall of the inner pipe toward the interior of the inner pipe, and is a portion at which the gas flow downstream side end portion is separated from the peripheral wall. The outside deformation portion is formed by deforming a portion of the peripheral wall adjacent to the gas flow downstream side end portion of the inside deformation portion toward the exterior of the inner pipe, and is a portion at which the gas flow upstream side end portion is separated from the peripheral wall. The hole of the communication portion is formed by the downstream side end portion of the inside deformation portion and the upstream side end portion of the outside deformation portion that are both separated from the peripheral wall. The hole is therefore hidden by the inside deformation portion, as viewed from the upstream side of the communication portions inside the inner pipe. Accordingly, fine particles, such as soot contained in the exhaust gas, hit the inside deformation portion, and so the fine particles do not easily block the hole in the communication portion.

[0009] Moreover, as described above, the communication portions are each formed by the downstream side end portion of the inside deformation portion and the upstream side end portion of the outside deformation portion. This enables the height of the inside deformation portion (amount of deformation toward the interior of the inner pipe) to be reduced while still securing the size of the hole, compared to a case in which the communication portion includes the inside deformation portion alone. Namely, increases in ventilation resistance may be prevented by providing the communication portions.

[0010] In the present aspect, the profile of the hole may be substantially an ellipse with the direction of the major axis aligned with the peripheral direction of the inner pipe.

[0011] In such a configuration, the profile of the hole is substantially an ellipse with the direction of the major axis of the substantially elliptical shape aligned with the peripheral direction of the inner pipe. This enables the height of the inside deformation portion (amount of deformation toward the inner pipe inside) to be set small while still securing the size of the hole.

[0012] This enables increases in ventilation resistance

caused by the communication portion to be further reduced.

[0013] Alternatively, in the present aspect, the profile of the hole may be a substantially rectangular shape with a length direction aligned with the peripheral direction of the inner pipe.

[0014] This configuration also enables the height of the inside deformation portion (amount of deformation toward the interior of the inner pipe) to be set small while still securing the size of the hole, and enables increases in ventilation resistance caused by the communication portion to be further reduced.

[0015] In the present aspect, the amount of deformation of the inside deformation portion toward the interior of the inner pipe may be less than the amount of deformation of the outside deformation portion toward the exterior of the inner pipe.

[0016] In this muffler, the amount of deformation of the inside deformation portion toward the interior of the inner pipe is less than the amount of deformation of the outside deformation portion toward the exterior of the inner pipe. This enables the height of the inside deformation portion (amount of deformation toward the inner pipe inside) to be set small while still securing the size of the hole, as long as the amount of deformation of the outside deformation portion toward the pipe outside is large.

[0017] This enables increases in ventilation resistance caused by the communication portion to be further reduced.

[0018] In the present aspect, the cross-sectional profiles of the inside deformation portion and the outside deformation portion taken along planes orthogonal to the inner pipe peripheral direction may be shaped approximately as arcs of a circle or an ellipse.

[0019] Such a configuration enables numerous communication portions to be formed along the inner pipe length direction, and this enables muffling effects to be improved.

[0020] In the present aspect, the inside deformation portion and the outside deformation portion may include a parallel portion that runs parallel to the direction of gas flow.

[0021] In a muffler including the deformation portion having such a configuration, increases in ventilation resistance may be prevented due to the flow rectification action performed on the exhaust gas.

[0022] As explained above, the muffler of the present aspect makes it difficult for fine particles such as soot to block small holes placing the interior and exterior of an inner pipe in communication with each other, without a large attendant increase in ventilation resistance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Exemplary embodiments of the present invention will be described in detail based on the following figures, wherein:

Fig. 1 is a perspective view of one communication portion of a plurality of communication portions formed in an inner pipe peripheral wall of a muffler according to an exemplary embodiment, as viewed from the interior of an inner pipe (exhaust gas flow path);

Fig. 2 is a cross-sectional view of the communication portion of Fig. 1 taken along line 2-2;

Fig. 3 is a cross-sectional view of the communication portion of Fig. 1 taken along line 3-3;

Fig. 4 is a perspective view of a muffler according to the present exemplary embodiment, in which an inner pipe is represented by a solid line, and an outer shell is represented by a double-dotted dashed line; Fig. 5A to Fig. 5D relate to other exemplary embodiments; Fig. 5A is a cross-sectional view corresponding to Fig. 2 showing a communication portion including a parallel portion; Fig. 5B is a cross-sectional view corresponding to Fig. 2 showing a communication portion formed with a spherical surface shape; Fig. 5C is a cross-sectional view corresponding to Fig. 3 showing a communication portion in which holes have substantially elliptical profiles; and Fig. 5D is a cross-sectional view corresponding to Fig. 3 showing a communication portion in which holes have substantially rectangular shapes; and Fig. 6 is a perspective view of a muffler according to another exemplary embodiment, in which an inner pipe is represented by a solid line, and an outer shell is represented by a double-dotted dashed line.

DETAILED DESCRIPTION

[0024] Detailed description of an exemplary embodiment of a muffler according to the present disclosure is made with reference to Fig. 1 to Fig. 4.

[0025] Fig. 4 illustrates a muffler 10 according to the present exemplary embodiment. As illustrated in Fig. 4, the muffler 10 is a muffler having a so-called straight structure in which a flow path for internally flowing exhaust gas is linear. The muffler 10 includes an outer shell 12 that forms an outermost wall of the muffler 10, and an inner pipe 14 that is inserted into the interior of the outer shell 12. The muffler 10 is disposed partway along a flow path that guides exhaust gas exhausted from an engine, not illustrated in the drawings, to the atmosphere.

[0026] The outer shell 12 includes a general portion 16 that has a tubular shape having a large diameter, two narrowing diameter portions 18 that narrow in diameter from both length direction ends of the general portion 16 toward both end portions 20 of the outer shell 12, and both of the end portions 20 are tubes having a narrow diameter and are joined to the inner pipe 14. The inner pipe 14 has a tubular shape having a narrower diameter than the general portion 16 of the outer shell 12 and substantially the same diameter as both of the end portions 20 of the outer shell 12, and is disposed coaxially to the outer shell 12. The interior of the inner pipe 14 is an ex-

haust gas flow path 22 through which exhaust gas G flows, and a portion internal to the outer shell 12 and external to the inner pipe 14 is a muffling chamber 24. A plurality of communication portions 28 (see Fig. 1), described in detail below, are formed in a peripheral wall 26 of the inner pipe 14, namely, a portion indicated by the diagonal lines in Fig. 4. The communication portions 28 place the exhaust gas flow path 22 in communication with the muffling chamber 24. Sound caused by the exhaust gas G flowing through the exhaust gas flow path 22 is transmitted to the muffling chamber 24 through the communication portions 28, and is muffled in the muffling chamber 24. A sound absorbing material (not illustrated in the drawings), such as stainless steel wool or glass wool, is disposed in the muffling chamber 24.

Communication Portion

[0027] Fig. 1 illustrates one communication portion 28 of the plurality of communication portions 28 formed in the peripheral wall 26 of the inner pipe 14, as viewed from the interior of the inner pipe 14 (the exhaust gas flow path 22). In the respective drawings, the arrow F indicates the gas flow direction in the length directions along the inner pipe 14, the arrow W indicates the peripheral direction of the peripheral wall 26 of the inner pipe 14, and the arrow H indicates the inner pipe inside direction along the thickness direction of the peripheral wall 26. Hereafter, the gas flow direction may be simply referred to as the "flow direction" and sides of an element may be referred to as the "downstream/upstream side" of the element with reference to the flow direction, the peripheral direction of the peripheral wall 26 of the inner pipe 14 may be simply referred to as the "peripheral direction", and the inner pipe inside direction along the thickness of the peripheral wall 26 may be simply referred to as the "pipe inside direction" or the "height direction". The opposite direction will be referred to as the "pipe outside direction".

[0028] As illustrated in Fig. 1, the communication portion 28 includes an inside deformation portion 30 formed by deforming a portion of the peripheral wall 26 toward the pipe inside direction, and an outside deformation portion 32 formed by deforming a portion of the peripheral wall 26 toward the pipe outside direction. The inside deformation portion 30 is contiguous to the peripheral wall 26 at a boundary portion 30A, and the inside deformation portion 30 is separated from the peripheral wall 26 at a downstream side end portion 30B. Likewise, the outside deformation portion 32 is contiguous to the peripheral wall 26 at a boundary portion 32A, and the outside deformation portion 32 is separated from the peripheral wall 26 at an upstream side end portion 32B.

[0029] The inside deformation portion 30 and the outside deformation portion 32 are provided adjacent to each other in the flow direction. A hole 34 in the peripheral wall 26 is thereby formed by the downstream side end portion 30B of the inside deformation portion 30 and the

upstream side end portion 32B of the outside deformation portion 32. The exhaust gas flow path 22 in the interior of the inner pipe 14 is in communication with the muffling chamber 24 at the exterior of the inner pipe 14 through this hole 34. Forming the hole 34 in this manner gives a configuration in which the hole 34 of the communication portion 28 is not visible from the upstream side of the communication portions 28 in the interior of the inner pipe 14. However, the hole 34 of the communication portion 28 is visible from the downstream side of the communication portions 28 in the interior of the inner pipe 14. Note that Fig. 1 is a schematic drawing of the communication portion 28 viewed from the downstream side of the communication portions 28 in the interior of the inner pipe 14, and the hole 34 is illustrated in Fig. 1.

[0030] The inner pipe 14 having the communication portions 28 formed in the peripheral wall 26 in this manner is, for example, manufactured by the following method. Firstly, a plurality of small notches, each notch extending along a width direction, are formed in a rectangular shaped metal plate. Secondly, portions that face each other in a length direction across the notches are deformed toward a front face side and toward a rear face side of the plate by deforming the metal plate with a press, for example by stamping the metal plate. Lastly, the rectangular shaped metal plate is wrapped to form a tube by joining width direction end portions thereof together. Due to forming in this manner, the inside deformation portion 30 has a louver form which projects toward the pipe inside direction and opens at the downstream side. Likewise, the outside deformation portion 32 has a louver form which projects toward the pipe outside direction and opens at the upstream side.

[0031] The inside deformation portion 30 is formed with a convex curved face protruding toward the pipe inside direction. Namely, as illustrated in Fig. 2, on a cross-section profile taken along line 2-2 of Fig. 1, i.e., along a plane orthogonal to the peripheral direction and passing by a center of the inside deformation portion 30 taken along the peripheral direction, the inside deformation portion 30 is substantially parallel to the gas flow direction in the vicinity of the downstream side end portion 30B (hole 34), and an angle of the inside deformation portion 30 with respect to the gas flow direction increases on progression away from the downstream side end portion 30B (hole 34) toward the upstream side. Moreover, as illustrated in Fig. 3, the inside deformation portion 30 is parallel to the peripheral direction at the center of the inside deformation portion 30 taken along the peripheral direction, and has an angle with respect to the peripheral direction that increases toward the boundary portion 30A, as viewed from the downstream side. Although Fig. 3 illustrates the downstream side end portion 30B of the inside deformation portion 30, when the inside deformation portion 30 is sectioned along any plane orthogonal to the direction of gas flow, the inside deformation portion 30 is parallel to the peripheral direction at a center of the inside deformation portion 30 taken along the peripheral

direction in said plane, and has an angle with respect to the peripheral direction that increases on progressing toward the boundary portion 30A.

[0032] The outside deformation portion 32 is formed with a convex curved face protruding toward the pipe outside direction. Namely, as illustrated in Fig. 2, in a cross-section profile taken along line 2-2 of Fig. 1, i.e., along a plane orthogonal to the peripheral direction and passing by a center of the outside deformation portion 32 taken along the peripheral direction, in the vicinity of the upstream side end portion 32B (hole 34), the outside deformation portion 32 is substantially parallel to the direction of gas flow, and an angle of the outside deformation portion 32 with respect to the gas flow direction increases from the upstream side end portion 32B (hole 34) toward the downstream side. Moreover, as indicated by the double-dotted dashed lines in Fig. 3, as viewed from the downstream side, the outside deformation portion 32 is parallel to the peripheral direction at the center of the outside deformation portion 32 taken along the peripheral direction, and has an angle with respect to the peripheral direction that increases toward the boundary portion 32A. Although the double-dotted dashed lines in Fig. 3 indicate the upstream side end portion 32B of the outside deformation portion 32, when the outside deformation portion 32 is sectioned along any plane orthogonal to the direction of gas flow, the outside deformation portion 32 is parallel to the peripheral direction at a center of the outside deformation portion 32 taken along the peripheral direction in said plane, and has an angle with respect to the peripheral direction that increases toward the boundary portion 32A. In other words, the communication portion 28 that includes the inside deformation portion 30 and the outside deformation portion 32 is shaped such that the downstream side half of a dome shape, formed so as to protrude toward the pipe inside direction, is inverted toward the pipe outside direction.

[0033] As illustrated in Fig. 3, the hole 34 of the communication portion 28 has a circular shape substantially orthogonal to the direction of gas flow. Namely, as illustrated in Fig. 2, the downstream side end portion 30B of the inside deformation portion 30 and the upstream side end portion 32B of the outside deformation portion 32 both form substantially right angles with respect to the peripheral wall 26. Moreover, the downstream side end portion 30B of the inside deformation portion 30 and the upstream side end portion 32B of the outside deformation portion 32 are both formed as semicircular shapes.

[0034] As illustrated in Fig. 2, an angle is formed between the inside deformation portion 30 and the peripheral wall 26 at the boundary portion 30A, at which the inside deformation portion 30 connects to the peripheral wall 26. Namely, the boundary portion 30A has a shape in which the peripheral wall 26 rises rapidly at the boundary portion 30A, without there being a gentle curved surface. Likewise, an angle is formed between the outside deformation portion 32 and the peripheral wall 26 at the boundary portion 32A, at which the outside deformation

portion 32 connects to the peripheral wall 26. Namely, the boundary portion 32A has a shape in which the peripheral wall 26 rises rapidly at the boundary portion 32A, without there being a gently curved surface.

[0035] As illustrated in Fig. 2, the dimension L_{in} of the inside deformation portion 30 along the direction of gas flow is larger than the dimension H_{in} of the inside deformation portion 30 along the pipe inside direction. Moreover, the dimension L_{out} of the outside deformation portion 32 along the direction of gas flow is larger than the dimension H_{out} of the outside deformation portion 32 along the pipe outside direction. Note that in the present exemplary embodiment, L_{in} and L_{out} are formed substantially equal to each other, and H_{in} and H_{out} are formed substantially equal to each other.

Operation and Effects

[0036] Next, explanation follows regarding operation and effects of the muffler 10 of the present exemplary embodiment.

[0037] In the muffler 10 of the present exemplary embodiment, the peripheral wall 26 of inner pipe 14 is formed with the plurality of communication portions 28, each including the hole 34, which places the exhaust gas flow path 22 in the interior the inner pipe in communication with the muffling chamber 24 at exterior of the inner pipe. Sound waves caused by exhaust gas flowing through the exhaust gas flow path 22 therefore enter the muffling chamber 24 via the hole 34, and are attenuated by the noise absorbing effect of the glass wool or stainless steel wool of the muffling chamber 24.

[0038] The communication portion 28 of the present exemplary embodiment also includes the inside deformation portion 30 and the outside deformation portion 32. The inside deformation portion 30 is formed by deforming a portion of the peripheral wall 26 of the inner pipe 14 toward the interior of the inner pipe, and is a portion at which the gas flow downstream side end portion 30B has separated from the peripheral wall 26. The outside deformation portion 32 is formed by deforming the portion of the peripheral wall 26 adjacent to the inside deformation portion 30 at the gas flow downstream side toward the exterior of the inner pipe, and is a portion at which the gas flow upstream side end portion 32B has separated from the peripheral wall 26. The hole 34 of the communication portion 28 is formed by the downstream side end portion 30B of the inside deformation portion 30 and the upstream side end portion 32B of the outside deformation portion 32 that are both separated from the peripheral wall 26. The hole 34 is therefore hidden by the inside deformation portion 30, as viewed from the upstream side of the communication portions 28 on the inside of the inner pipe 14. Accordingly, fine particles such as soot are prevented from blocking the hole 34, since fine particles such as soot contained in the exhaust gas G hit the inside deformation portion 30. Thus, the muffler 10 is particularly well suited to a vehicle equipped with

an engine in which soot is liable to be contained in exhaust gas, such as a direct-injection engine.

[0039] Moreover, in the present exemplary embodiment, as explained above, the hole 34 of the communication portion 28 is formed by the downstream side end portion 30B of the inside deformation portion 30 and the upstream side end portion 32B of the outside deformation portion 32. This enables the height H_{in} of the inside deformation portion 30 (amount of deformation toward the interior the inner pipe) to be reduced while still securing the size of the hole 34, compared to a case in which the communication portion 28 includes the inside deformation portion 30 alone. Namely, increases in ventilation resistance may be prevented by providing the communication portions 28. Namely, ventilation resistance for the exhaust gas G may be lowered in the muffler 10, while still securing muffling performance.

[0040] Moreover, the outside deformation portion 32 of the present exemplary embodiment fulfils the role of fixing the glass wool or stainless steel wool on the exterior of the inner pipe 14 in a specific position. This prevents positional displacement of sound absorbing material, such as glass wool or stainless steel wool, in the muffler 10.

[0041] Moreover, the communication portions 28 of the present exemplary embodiment may be manufactured by cutting a notch in the peripheral wall 26 of the inner pipe 14, and then deforming the peripheral wall 26 with a press. Accordingly, no waste is generated by cutting the peripheral wall 26 during manufacturing process. Moreover, burrs (protuberances), not illustrated in the drawings, are generated during manufacture of the communication portions 28 at the downstream side end portion 30B of the inside deformation portion 30 and the upstream side end portion 32B of the outside deformation portion 32; however, these burrs are formed facing the inside direction of the hole 34. Accordingly, the burrs do not cause ventilation resistance for the exhaust gas G. Moreover, the burrs do not damage the glass wool or stainless steel wool disposed at the outside of the inner pipe 14.

[0042] Moreover, it is conceivable that the turbulent flow in the exhaust gas G flowing through the exhaust gas flow path 22 would be caused by the inside deformation portion 30 being deformed toward the exterior of the inner pipe. However, in the present exemplary embodiment, turbulent flow in the exhaust gas G is reduced or even eliminated since the inside deformation portion 30 is formed with a curved face convex protruding toward the pipe inside direction.

Supplementary Explanation of Above Exemplary Embodiment

[0043] Note that in the exemplary embodiment described above, the cross-section profiles, given by sectioning the inside deformation portion 30 and the outside deformation portion 32 along a plane orthogonal to the

peripheral direction (the cross-section profile illustrated in Fig. 2), are formed so as to be shaped approximately as arcs of an ellipse; however, the "communication portion" of the present disclosure is not limited thereto. For example, a communication portion 128 or a communication portion 228, having cross-section profiles like those illustrated in Fig. 5A and Fig. 5B, may be employed.

[0044] In the communication portion 128 illustrated in Fig. 5A, an inside deformation portion 130 includes a parallel portion 130C parallel to the flow direction. An end portion at the downstream side of the parallel portion 130C forms a downstream side end portion 130B of the inside deformation portion 130. Likewise, an outside deformation portion 132 includes a parallel portion 132C parallel to the flow direction. An end portion at the upstream side of the parallel portion 132C forms an upstream side end portion 132B of the outside deformation portion 132. A flow rectification action is accordingly performed on the exhaust gas and an increase in ventilation resistance in the muffler provided with the communication portion 128 is reduced or even eliminated. Moreover, in the communication portion 128, the peripheral wall 26 and boundary portions 130A, 132A are formed as gently curved faces.

[0045] A cross-section profile of the communication portion 228, illustrated in Fig. 5B, sectioned along a plane orthogonal to the peripheral direction, forms a circular arc shape in the communication portion 228. Namely, an inside deformation portion 230 and an outside deformation portion 232 are each shaped as one quarter of a divided sphere. Thus, numerous communication portions 228 may be formed along the inner pipe length direction in the muffler provided with the communication portion 228.

[0046] Moreover, in the above exemplary embodiment, the hole 34 of the communication portion 28 has a circular shape as viewed along the downstream direction (see Fig. 3); however, the present disclosure is not limited thereto. For example, a communication portion 328 or a communication 428 having holes 34 as illustrated in Fig. 5C and Fig. 5D may be employed.

[0047] In the communication portion 328 illustrated in Fig. 5C, the hole 34 has a substantially elliptical profile, with a height dimension smaller than the width dimension thereof. Namely, the hole 34 has a substantially elliptical profile, with the direction of the major axis of the substantially elliptical profile aligned with the peripheral direction of the peripheral wall 26 of the inner pipe 14. In this communication portion 328, while still securing the size of the holes, the ventilation resistance of the exhaust gas G may be lowered while securing muffling performance, since the height dimension H_{in} of the inside deformation portion 30 may be smaller than the height dimension H_{in} of a muffler in which the communication portion includes the inside deformation portion alone.

[0048] The hole 34 is formed with a substantially rectangular profile in the communication portion 428 illustrated in Fig. 5D. A muffler including the communication

portion 428 is included in the present disclosure.

[0049] Moreover, although the height dimension H_{in} of the inside deformation portion 30 and the height dimension H_{out} of the outside deformation portion 32 are set substantially equal to each other in the above exemplary embodiments, the present disclosure is not limited thereto. For example, the height dimension H_{in} of the inside deformation portion 30 may be set smaller than the height dimension H_{out} of the outside deformation portion 32. In such cases, the height of the inside deformation portion 30 may be smaller while securing the size of the hole, thereby enabling increases in ventilation resistance to be further reduced.

[0050] Moreover, although the muffler 10 is a so-called straight type muffler in the above exemplary embodiments, the "muffler" of the present disclosure is not limited thereto. For example, as illustrated in Fig. 6, a muffler 510 that does not present an overall straight structure may be employed. In the muffler 510, the interior of an outer shell 512 is divided into a first muffling chamber 524A, a second muffling chamber 524B, and a third muffling chamber 524C, by a first separator 540 and a second separator 542. An explanation of flow of the exhaust gas G in this muffler 510 is given hereafter. Firstly, the exhaust gas G flows through the interior of an introducing pipe 514A, and is introduced into the third muffling chamber 524C. Next, the exhaust gas G introduced into the third muffling chamber 524C flows through the interior of an intermediate pipe 514B, and is introduced into the first muffling chamber 524A. Finally, the exhaust gas G introduced into the first muffling chamber 524A flows through the interior of a lead-out pipe 514C and is led out to the exterior of the muffler 510. Namely, the flow direction in which the exhaust gas G flows through the interior is linear in each one of the introducing pipe 514A, the intermediate pipe 514B, and the outlet pipe 514C.

[0051] In the muffler 510 formed in this manner, communication portions may be formed in the peripheral walls of all or in at least one of the introducing pipe 514A, the intermediate pipe 514B, and the outlet pipe 514C (the portions indicated by the diagonal lines in Fig. 6). Namely, the inner pipe provided with the muffler of the present disclosure is one in which exhaust gas flows internally in a specific direction when the engine is running with a muffling chamber formed at the exterior of the inner pipe, and the specific structure of the muffler 10 is not particularly limited.

[0052] Moreover, although a sound absorbing material such as glass wool or stainless steel wool is disposed in the interior of the muffling chamber in the above exemplary embodiments, the "muffling chamber" of the present disclosure is not limited thereto. The interior of the muffling chamber may be empty. Moreover, although the muffling chamber 24 is formed by the outer shell 12 and the inner pipe 14 in the above exemplary embodiments, the "muffling chamber" of the present disclosure is not limited thereto. "Muffling chambers" of the present disclosure include any chambers formed at the exterior

of an inner pipe.

Claims

1. A muffler (10; 510) comprising:

an inner pipe (14; 514A, 514B, 514C) that is inserted into an interior of an outer shell (12; 512); and
a plurality of communication portions (28) that are formed in a peripheral wall (26) of the inner pipe (14; 514A, 514B, 514C), and that include holes (34) that place an exhaust gas flow path (22) in an interior of the inner pipe in communication with a muffling chamber (24) at an exterior of the inner pipe,
wherein each of the communication portions (28) comprises:

an inside deformation portion (30; 130; 230; 330; 430) that is formed by deforming a portion of the peripheral wall (26) toward the interior of the inner pipe, and that has a gas flow downstream side end portion (30B) separated from the peripheral wall (26); and
an outside deformation portion (32; 132; 232; 332; 432) that is formed by deforming a portion of the peripheral wall (26) adjacent to the gas flow downstream side end portion (30B) of the inside deformation portion (30) toward the exterior of the inner pipe, and that has a gas flow upstream side end portion (32B) separated from the peripheral wall (26), and

wherein the hole (34) is formed by the downstream side end portion (30B) of the inside deformation portion (30; 130; 230; 330; 430) and the upstream side end portion (32B) of the outside deformation portion (32; 132; 232; 332; 432).

2. The muffler (10; 510) of claim 1, wherein the profile of the hole (34) is substantially an ellipse with the direction of the major axis aligned with the peripheral direction (W) of the inner pipe (14; 514A, 514B, 514C).

3. The muffler (10; 510) of claim 1, wherein the profile of the hole (34) is a substantially rectangular shape with a length direction aligned with the peripheral direction (W) of the inner pipe (14; 514A, 514B, 514C).

4. The muffler (10; 510) of any one of claim 1 to claim 3, wherein the amount of deformation of the inside deformation portion (30; 130; 230; 330; 430) toward

the interior of the inner pipe (14; 514A, 514B, 514C) is smaller than the amount of deformation of the outside deformation portion (32; 132; 232; 332; 432) toward the exterior of the inner pipe (14; 514A, 514B, 514C).

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5. The muffler (10; 510) of any one of claim 1 to claim 4, wherein the cross-section profiles of the inside deformation portion (30; 130; 230; 330; 430) and the outside deformation portion (32; 132; 232; 332; 432) taken along planes orthogonal to the inner pipe peripheral direction (W) are shaped approximately as arcs of a circle or an ellipse.

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6. The muffler (10; 510) of any one of claim 1 to claim 4, wherein the inside deformation portion (30; 130; 230; 330; 430) and the outside deformation portion (32; 132; 232; 332; 432) include a parallel portion that runs parallel to the direction of gas flow.

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FIG.1

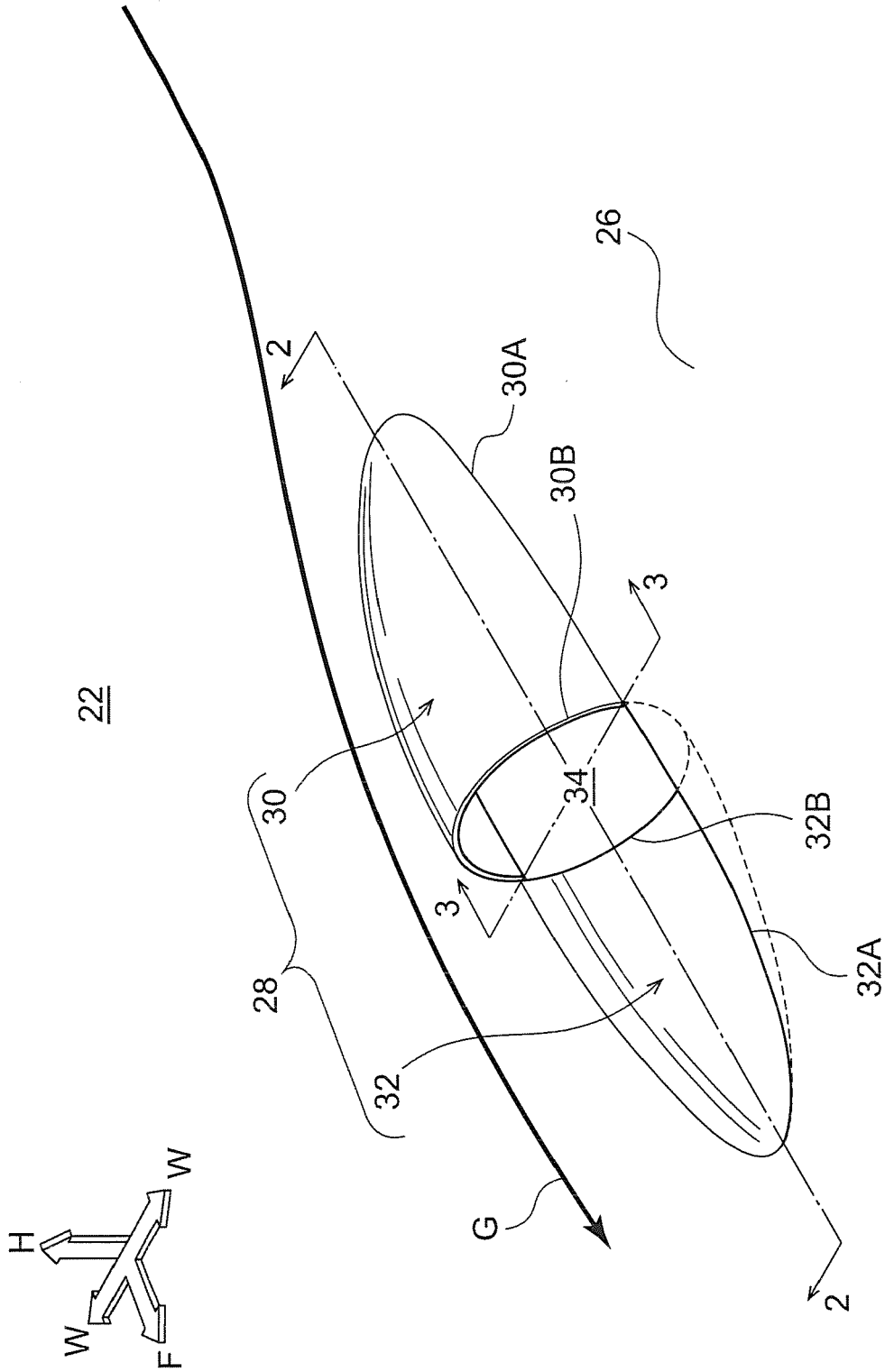


FIG.2

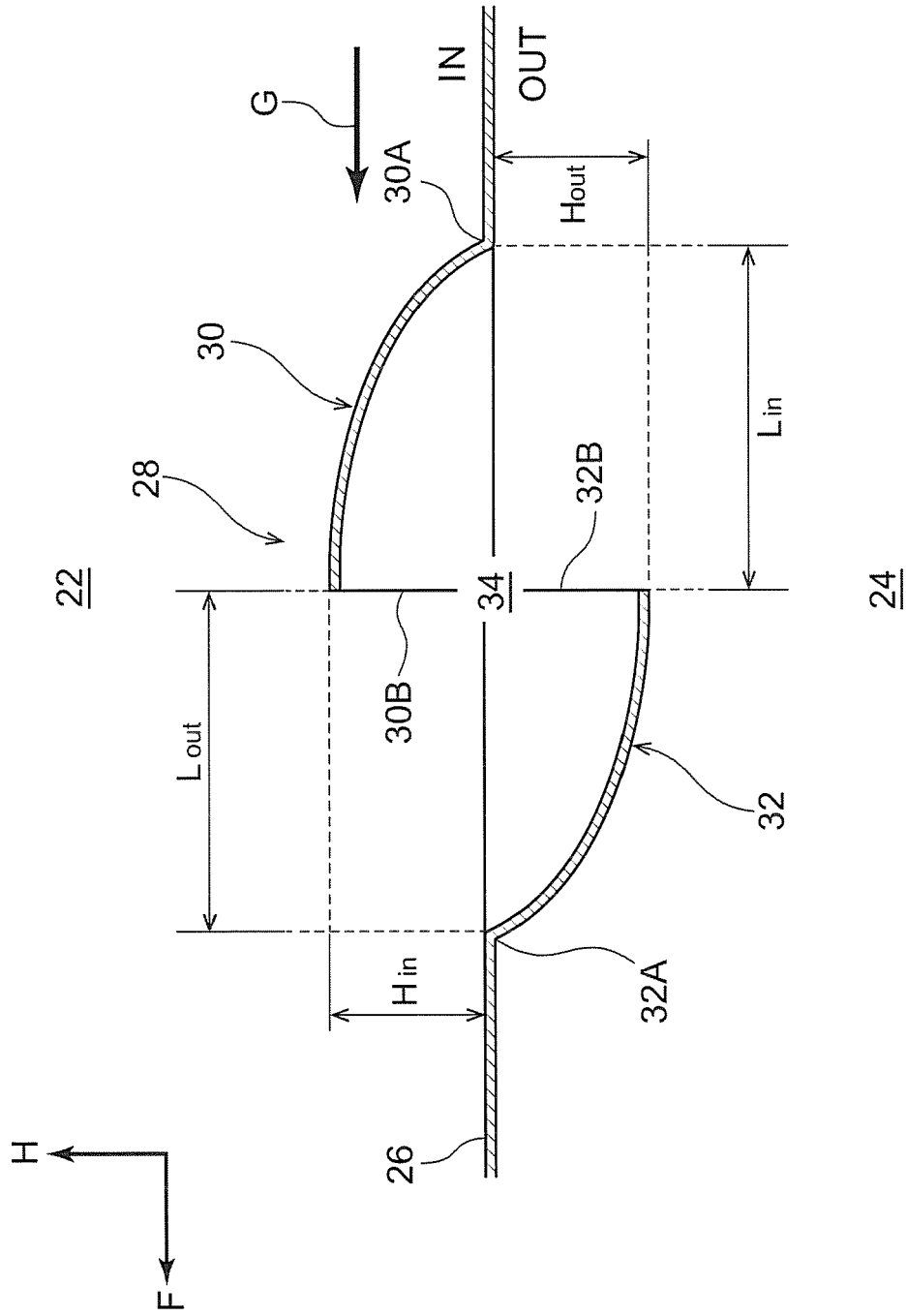


FIG.3

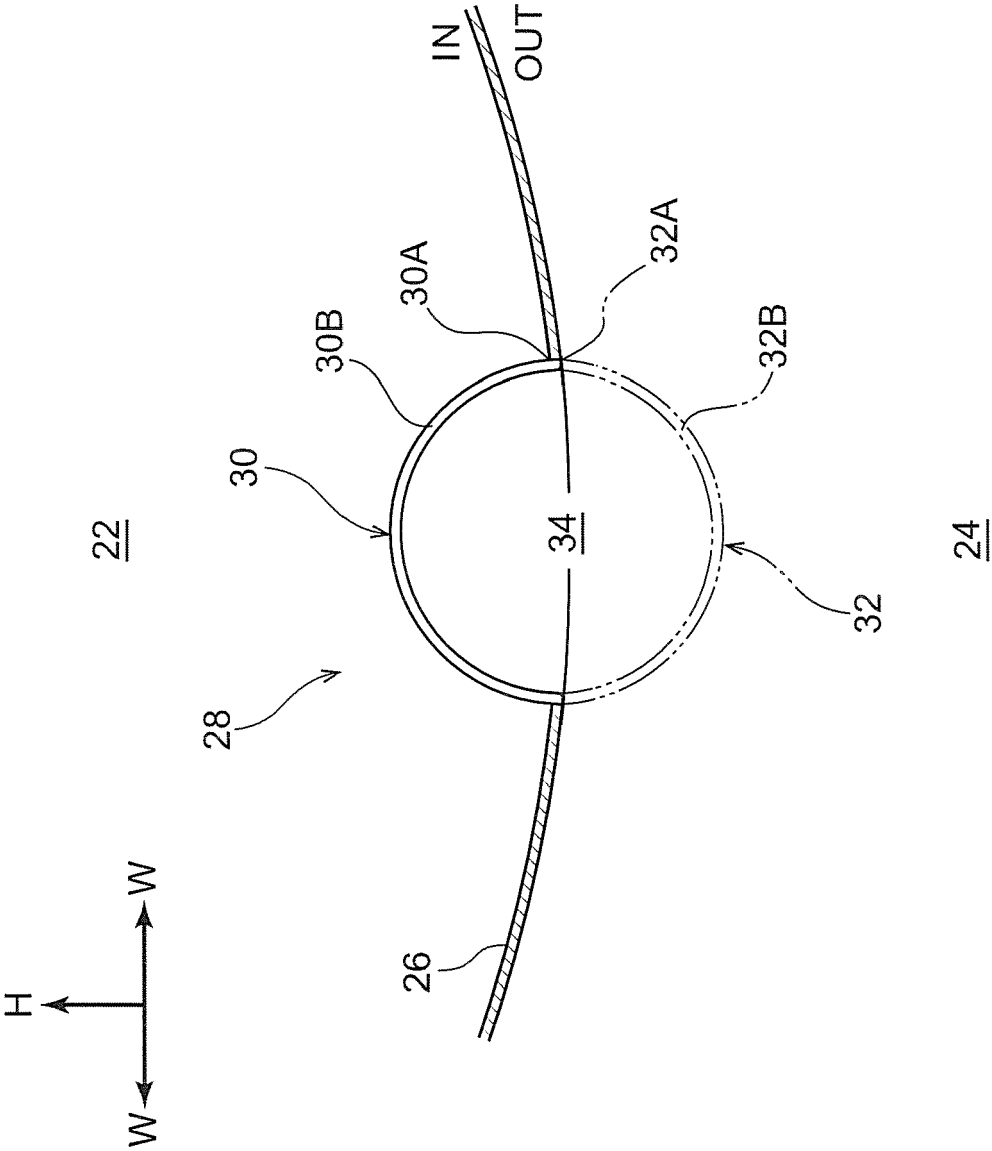


FIG.4

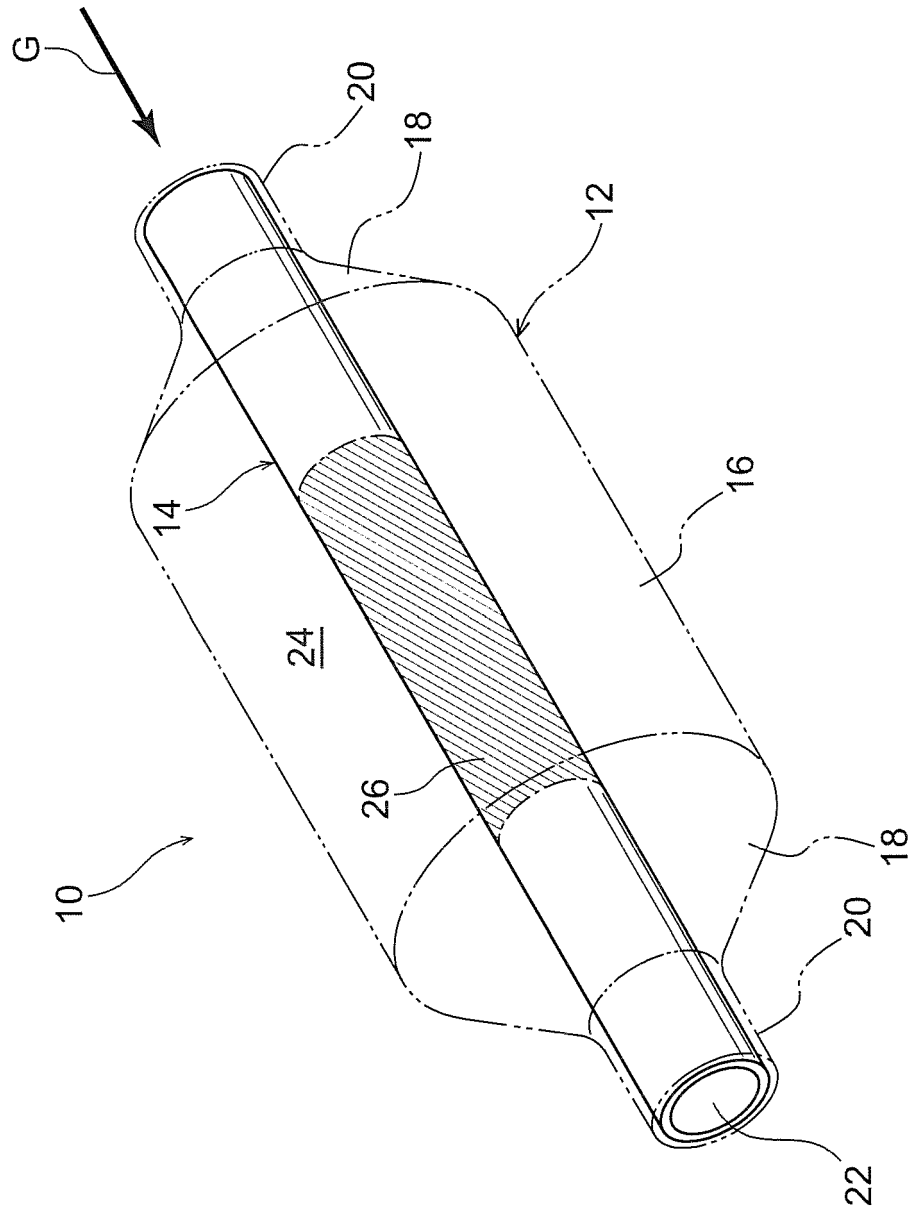


FIG.5A

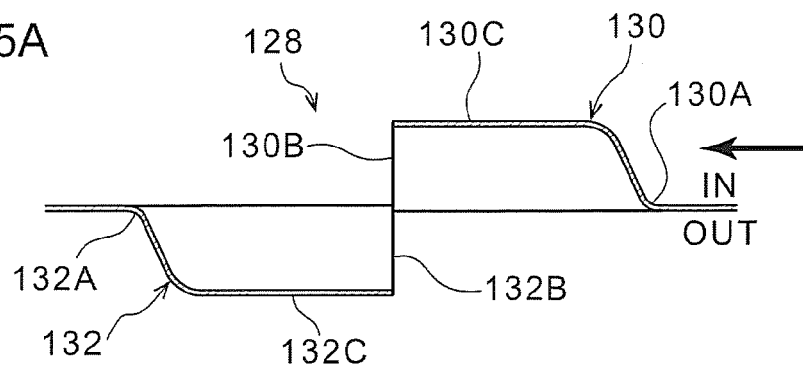


FIG.5B

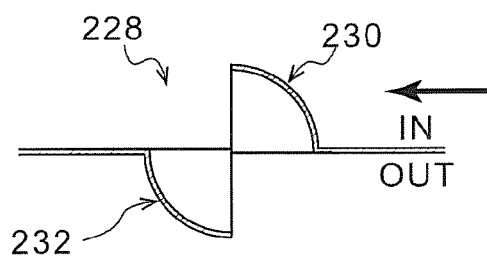


FIG.5C

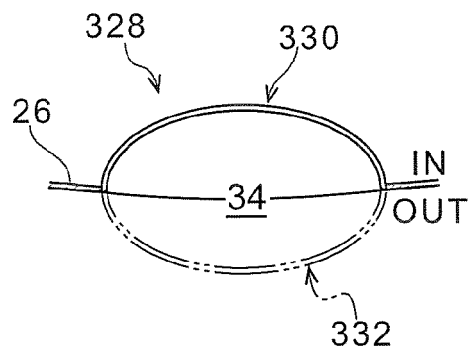


FIG.5D

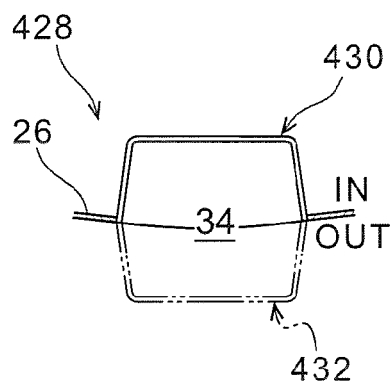
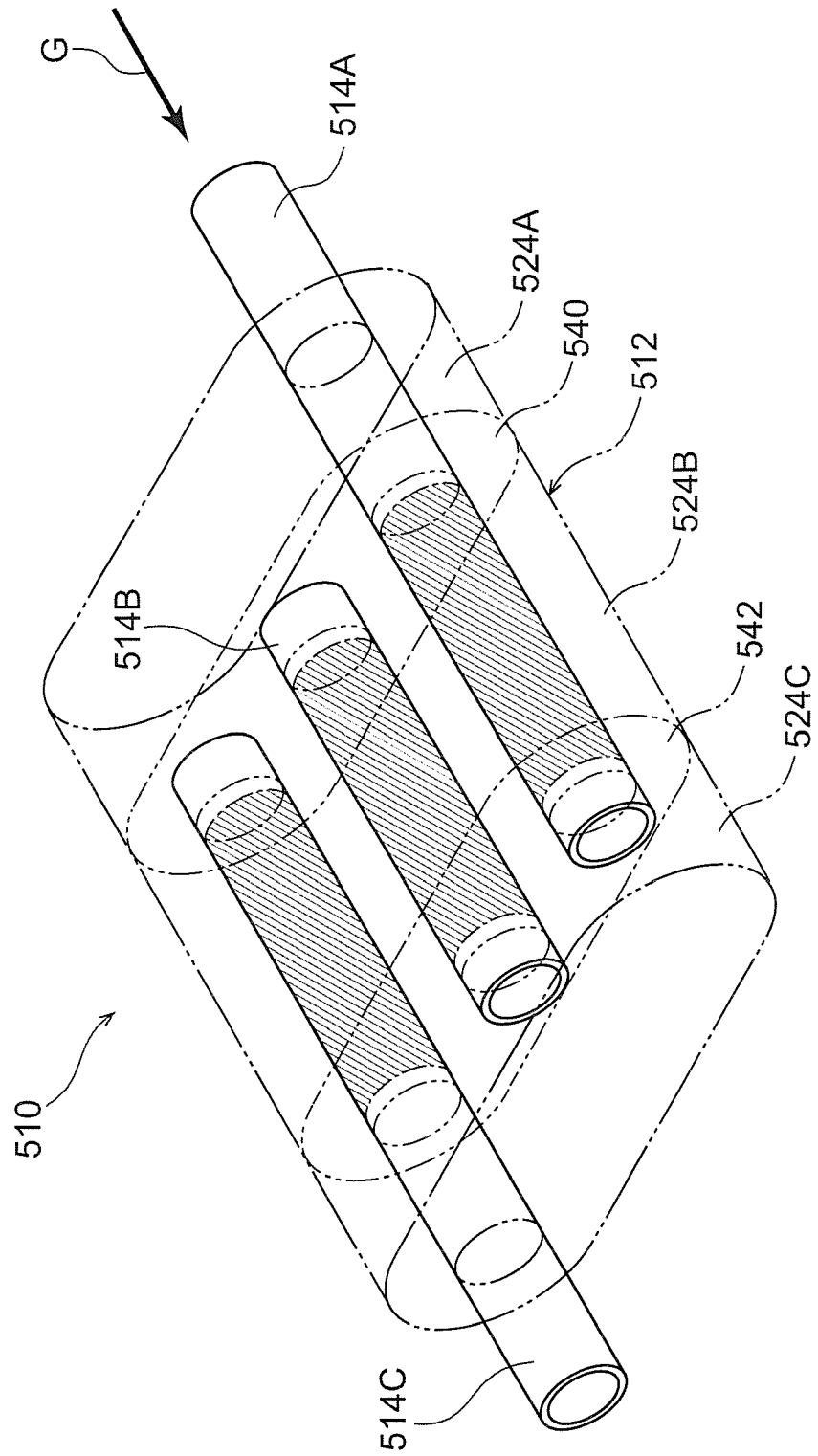


FIG.6





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Place of search Munich		Date of completion of the search 12 August 2016	Examiner Álvarez Goiburu, G
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