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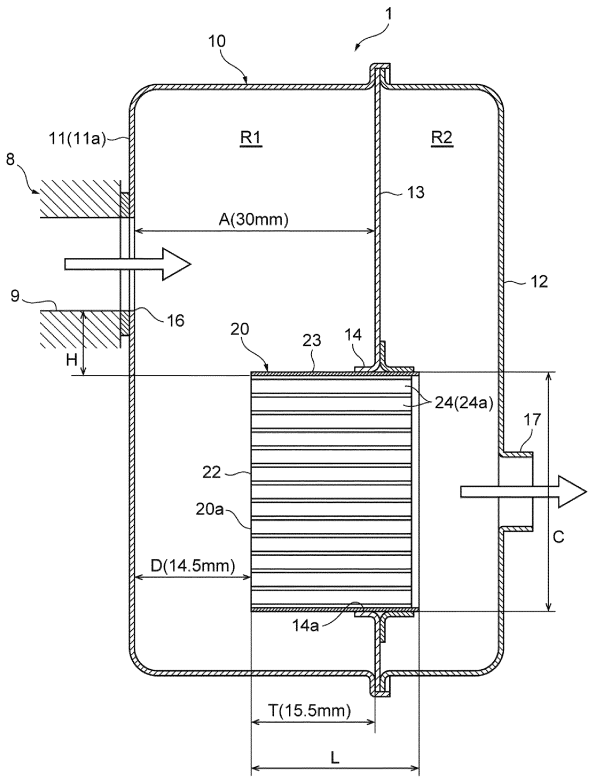
(54) MUFFLER FOR STRATIFIED SCAVENGING ENGINE

(57) A cost-effective muffler for a stratified scavenging engine capable of reducing the number of cells with no exhaust gas flowing in a columnar catalyst as much as possible to create a uniform exhaust gas flow in the columnar catalyst and thus obtaining a desired exhaust gas purification rate, so that THC emissions can be effectively curbed, without substantial alteration or dimensional changes to an existing muffler body and columnar catalyst. At least one of distances: from introduction port 16 to partitioning wall plate 13; from front wall surface 11a of front chamber RI to front end surface 20a of the columnar catalyst 20; and from partitioning wall plate 13 to front end surface 20a of the columnar catalyst 20 is within a predetermined range to prevent gas flow introduced into the front chamber RI through the introduction port 16 and hitting against the partitioning wall plate 13 to be reversed from bypassing cells in the upper end portion of the columnar catalyst 20 as much as possible.

Fig. 1



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Description

BACKGROUND

Technical Field

[0001] The present invention relates to a muffler with a built-in catalyst for exhaust gas purification for use in a stratified scavenging engine suitable for portable power working machines such as brush cutters, chain saws, and power blowers.

Background Art

[0002] A stratified scavenging two-cycle (stroke) engine (hereinafter referred to as a stratified scavenging engine), in which scavenging air (also referred to as leading air, etc.) is blown to scavenge a combustion gas prior to supplying an air/fuel mixture to a combustion chamber, has conventionally been well known. Such a stratified scavenging engine reduces the blow-by of an uncombusted air/fuel mixture as compared to the conventional typical two-cycle engine, and thus can curb emissions of hazardous substances, such as THC (the total emission of HC components; also referred to as total hydrocarbon) (see Patent Literature 1, 2, and 3).

[0003] Some of the aforementioned stratified scavenging engines include a built-in monolithic form columnar catalyst for exhaust gas purification in the muffler provided in the exhaust system for further improving the exhaust gas purification performance (see Patent Literature 2 and 3).

[0004] An example of such a muffler for a stratified scavenging engine having a built-in monolithic form columnar catalyst will be briefly described by referring to a schematic view of FIG. 6.

[0005] A muffler 4 in the illustrated example includes a box container-shaped muffler body 10 having a square plate-shaped front chamber panel 11 with an opening on its one side, which defines a front chamber R1, and a square plate-shaped rear chamber panel 12 with an opening on its one side, which defines a rear chamber R2. A partitioning wall plate 13 is disposed inside the muffler body 10 so as to be sandwiched between the front chamber panel 11 and the rear chamber panel 12, the partitioning wall plate 13 hermetically partitioning the inside of the muffler body 10 into the front chamber R1 and the rear chamber R2.

[0006] An upper half portion of a front wall surface 11a of the front chamber R1 is provided with an introduction port 16 through which an exhaust gas is introduced from an exhaust port 9 provided in a cylinder 8 of the stratified scavenging engine. The partitioning wall plate 13 is disposed vertically to the direction in which the exhaust gas is introduced.

[0007] A monolithic form columnar catalyst 20 for exhaust gas purification is securely attached to roughly a lower half portion of the partitioning wall plate 13, so as to extend over the front chamber R1 and the rear chamber R2, with its axis orthogonal to the partitioning wall plate 13.

[0008] The aforementioned columnar catalyst 20 is an oxidation catalyst capable of oxidizing and combusting the THC such as uncombusted fuel components contained in the exhaust gas and includes a metallic or ceramic carrier 22 provided with multiple cells 24 in a grid pattern, each cell 24 having a linear passage 24a that allows the front chamber R1 and the rear chamber R2 to communicate with each other. The inside (each cell 24) of the carrier 22 is coated with an oxidation catalyst material of a platinum group, such as platinum and rhodium, and a metallic cylindrical shell 23 is externally fitted and secured to the outer periphery of the carrier 22.

Citation List

Patent Literature

[0009]

Patent Literature 1: US 6591606 B

Patent Literature 2: US 6647713 B

Patent Literature 3: JP 2020-63700 A

SUMMARY

[0010] The aforementioned built-in columnar catalyst of the muffler is easy to produce as compared to a prismatic catalyst. However, the built-in columnar catalyst has a disadvantage in that when the sizes in the longitudinal and lateral directions are the same, the cross-sectional area is reduced, which lowers the rate of exhaust gas purification.

[0011] To offset such a disadvantage, it is important to uniformly flow the exhaust gas in the columnar catalyst.

[0012] Further, in the aforementioned stratified scavenging engine, since scavenging air, an uncombusted air/fuel mixture, and a combustion gas are introduced into the muffler in this order, these gases are uniformly mixed and then flown into the catalyst, so that the catalyst can effectively use the oxygen in the air.

[0013] However, when multiple mufflers were prepared by differentiating the positions of the partitioning wall plate 13 and the columnar catalyst 20 in the front-back direction (the direction in which the exhaust gas is introduced) from those of one another, and the gas flow and gas flow velocity within the muffler and the columnar catalyst of each muffler were visualized for analysis by conducting a computer simulation and using a high-speed camera and a PIV (Particle Image Velocimetry), the following problems to be addressed were revealed.

[0014] Specifically, in the muffler 4 shown in FIG. 6, the exhaust gas containing the combustion gas, the scavenging air, and the blow-by of the uncombusted air/fuel

mixture from the exhaust port 9 provided in the cylinder 8 of the stratified scavenging engine is introduced straight into the front chamber R1 through the introduction port 16 and hits intensely against the partitioning wall plate 13 to be reversed and mixed by diffusion. However, depending on the dimensions of each part of the muffler 4, the reversed gas flow in an upper portion of the columnar catalyst 20 bypasses (takes a shortcut) a portion of a plurality of rows of cells in an upper end portion of the columnar catalyst 20, as shown by a white arrow in FIG. 6.

[0015] Specifically, as seen from the gas flow and gas flow velocity within a muffler (A) and a columnar catalyst (B) that are visualized in grayscale of an analysis model 4M shown in FIG. 7 that simulates the muffler 4 of FIG. 6, the reversed gas flow in the upper portion of the columnar catalyst 20 bypasses a portion of a plurality of rows of cells 24 in the upper end portion of the columnar catalyst 20, and thus, the gas scarcely flows in the portion (portion in white) of the plurality of rows of cells 24 that the gas flow bypasses, thus failing to perform exhaust gas purification through oxidation combustion in this portion. Therefore, there has been a problem in that a desired exhaust gas purification rate cannot be obtained with such a catalyst 20 in some cases, thus failing to sufficiently curb the THC emissions.

[0016] Herein, the most typical measure to improve the exhaust gas purification rate of the catalyst is to configure the catalyst such that its capacity is increased to lower the gas flow velocity within the muffler so as to allow the catalyst to be entirely filled with the gas. However, increasing the capacity of the catalyst also increases the weight and cost and further, could involve alteration or enlargement of the muffler itself having a built-in catalyst. Thus, such a measure is not advantageous in terms of cost effectiveness. Meanwhile, in the case of the catalyst simply downsized, as described above on the basis of FIG. 6, the gas flow hitting intensely against the partitioning wall plate reaches only a portion of the catalyst, thereby creating a local flow.

[0017] The present invention has been made in view of the foregoing and provides a cost-effective muffler for a stratified scavenging engine capable of reducing the number of cells where the exhaust gas does not flow in the columnar catalyst as much as possible to create a uniform exhaust gas flow in the columnar catalyst and thus obtaining a desired exhaust gas purification rate, so that the THC emissions can be effectively curbed, without making any substantial alteration or dimensional changes to an existing muffler body and columnar catalyst.

[0018] To achieve the foregoing, the inventors of the present invention conducted elaborate study and obtained the following findings.

[0019] Specifically, it was found that the phenomenon as described with reference to FIG. 6 and FIG. 7, in which the gas flow in the upper portion of the columnar catalyst 20 hitting intensely against the partitioning wall plate 13 to be reversed bypasses a portion of a plurality of rows of cells 24 in the upper end portion of the columnar catalyst 20, can be prevented by setting, within a predetermined range, at least one of a distance A from the introduction port 16 to the partitioning wall plate 13, a distance D from the front wall surface 11a of the front chamber R1 to a front end surface 20a of the columnar catalyst 20, or a distance T (the length of the catalyst 20 extending into the front chamber R1) from the partitioning wall plate 13 to the front end surface 20a of the columnar catalyst 20.

[0020] The muffler for a stratified scavenging engine according to the present invention has been made on the basis of the aforementioned findings and study based thereon, and basically includes: a muffler body that introduces and discharges an exhaust gas from a stratified scavenging engine; a partitioning wall plate disposed inside the muffler body vertically to a direction in which the exhaust gas is introduced, the partitioning wall plate hermetically partitioning the muffler body into a front chamber and a rear chamber on a downstream side of the front chamber, an upper half portion of the front chamber provided with an introduction port for introducing the exhaust gas; and a columnar catalyst for exhaust gas purification attached to roughly a lower half portion of the partitioning wall plate so as to extend over the front chamber and the rear chamber, with an axis of the columnar catalyst orthogonal to the partitioning wall plate, in which the columnar catalyst is a monolithic form catalyst provided with multiple cells in a grid pattern, each cell having a linear passage that allows the front chamber and the rear chamber to communicate with each other, and at least one of the distance A from the introduction port to the partitioning wall plate, the distance D from a front wall surface of the front chamber to a front end surface of the columnar catalyst, or the distance T from the partitioning wall plate to the front end surface of the columnar catalyst is set to be within a predetermined range so as to prevent a gas flow introduced into the front chamber through the introduction port and hitting against the partitioning wall plate to be reversed from bypassing the cells in an upper end portion of the columnar catalyst as much as possible.

[0021] In a preferred aspect, part of the gas flow reversed also enters the cells in the upper end portion of the columnar catalyst while being guided to an outer periphery surface of a cylindrical shell provided in an outer periphery of the columnar catalyst.

[0022] In another preferred aspect, the columnar catalyst is an oxidation catalyst, a redox catalyst, or a three-way catalyst capable of oxidation combusting at least an uncombusted fuel component contained in the exhaust gas.

[0023] In still another preferred aspect, a catalyst attachment portion is provided in roughly the lower half portion of the partitioning wall plate, the catalyst attachment portion having a circular insertion hole for enabling the columnar catalyst to be secured at any position in a direction orthogonal to the partitioning wall plate.

[0024] In another preferred aspect, the columnar catalyst is hermetically attached to the catalyst attachment

portion through welding.

[0025] In further another preferred aspect, the capacity of the front chamber is set to four to six times the displacement of the stratified scavenging engine.

[0026] In further another preferred aspect, the distance A from the introduction port to the partitioning wall plate is set to be within a range of 21.5 mm or greater, the distance D from the front wall surface of the front chamber to the front end surface of the columnar catalyst is set to be within a range of 5 mm or greater, the distance T from the partitioning wall plate to the front end surface of the columnar catalyst is set to be within a range of 7 mm or greater, and a distance H from a lower end of the introduction port to an upper end of the columnar catalyst is set to be within a range of 9 mm or greater.

[0027] In further another preferred aspect, the distance A from the introduction port to the partitioning wall plate is set to be within a range of 25 to 30 mm, the distance D from the front wall surface of the front chamber to the front end surface of the columnar catalyst is set to be within a range of 5 to 20 mm, the distance T from the partitioning wall plate to the front end surface of the columnar catalyst is set to be within a range of 7 to 16 mm, and the distance H from the lower end of the introduction port to the upper end of the columnar catalyst is set to be within a range of 9 to 20 mm.

[0028] In further another preferred aspect, the displacement of the stratified scavenging engine is within a range of 20 to 40 cc and a diameter C and a length L of the columnar catalyst are within a range of 25 to 50 mm and a range of 15 to 35 mm, respectively.

[0029] In the muffler for a stratified scavenging engine according to the present invention, without making any changes to the outside dimensions of the muffler body, the position of the introduction port, the diameter and length of the columnar catalyst, and the position of the columnar catalyst in the height direction in the muffler body of an existing muffler, at least one of the distance A from the introduction port to the partitioning wall plate, the distance D from the front wall surface of the front chamber to the front end surface of the columnar catalyst, or the distance T (the length of the catalyst extending into the front chamber) from the partitioning wall plate to the front end surface of the columnar catalyst is set to be within a predetermined range, so as to prevent the exhaust gas introduced into the front chamber through the introduction port and hitting against the partitioning wall plate to be reversed from bypassing the cells in the upper end portion of the columnar catalyst as much as possible.

[0030] Therefore, part of the gas flow hitting against the partitioning wall plate to be reversed also enters the cells in the upper end portion of the columnar catalyst while being guided to the outer periphery surface of the cylindrical shell provided in the outer periphery of the columnar catalyst. In this manner, the number of cells where the exhaust gas does not flow in the columnar catalyst can be reduced as much as possible to create a uniform exhaust gas flow in the columnar catalyst. As a result, a desired exhaust gas purification rate can be obtained and the THC emissions can be effectively curbed.

[0031] Moreover, the muffler for a stratified scavenging engine according to the present invention is cost effective, since an existing muffler part including a columnar catalyst can be used by making a simple adjustment to, for example, the distance T from the partitioning wall plate to the front end surface of the columnar catalyst, that is, the length of the catalyst extending into the front chamber (the position of the catalyst in the axial direction relative to the partitioning wall plate) on the basis of the results of experiments for analysis conducted in advance using a computer or the like, so that the functional effects as described above can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032]

FIG. 1 is a schematic cross-sectional view of an embodiment (Example 1) of a muffler for a stratified scavenging engine according to the present invention;

FIG. 2 shows views of a gas flow and a gas flow velocity within a muffler (A) and a columnar catalyst (B) that are visualized in grayscale of an analysis model that simulates the muffler shown in FIG. 1;

FIG. 3 is a schematic cross-sectional view of an embodiment (Example 2) of the muffler for a stratified scavenging engine according to the present invention;

FIG. 4 shows views of a gas flow and a gas flow velocity within the muffler (A) and the columnar catalyst (B) that are visualized in grayscale of an analysis model that simulates the muffler shown in FIG. 3;

FIG. 5 is a schematic cross-sectional view of an embodiment (Example 3) of the muffler for a stratified scavenging engine according to the present invention;

FIG. 6 is a schematic cross-sectional view of a muffler of an existing comparative product (Comparative Example) relative to the mufflers shown in FIG. 1 and the like;

FIG. 7 shows views of a gas flow and a gas flow velocity within the muffler (A) and the columnar catalyst (B) that are visualized in grayscale of an analysis model that simulates the muffler shown in FIG. 6;

FIG. 8 is a graph with the longitudinal axis representing the proportion of gas that does not pass through the catalyst and with the lateral axis representing the

distance of a partitioning wall plate from a reference position, the graph showing the proportions of gas that does not pass through the catalyst when the positions of the partitioning wall plate and the columnar catalyst are changed;

FIG. 9 is a table showing the proportions of gas that does not pass through the catalyst when the dimensional parameters of the mufflers, which are a distance A from an introduction port to the partitioning wall plate and a distance D from a front wall surface of a front chamber to a front end surface of the columnar catalyst, are changed; and

FIG. 10 is a graph with the longitudinal axis representing a length T (A-D) of the catalyst extending into the front chamber and with the lateral axis representing the distance A from the introduction port to the partitioning wall plate, the graph showing regions classified by three levels of proportions of gas that does not pass through the catalyst.

DETAILED DESCRIPTION

[0033] The embodiments of the present invention will be described below with reference to the drawings.

[0034] FIG. 1, FIG. 3, and FIG. 5 are schematic cross-sectional views of embodiments (Examples 1, 2, and 3) of mufflers 1, 2, and 3, respectively, for a stratified scavenging engine according to the present invention, and FIG. 6 is a schematic cross-sectional view of the muffler 4 of an existing comparative product (Comparative Example).

[0035] Further, FIG. 2, FIG. 4, and FIG. 7 are views of a gas flow and a gas flow velocity within the muffler (A) and the columnar catalyst (B) that are visualized in grayscale of analysis models 1M, 2M, and 4M, respectively, the analysis models 1M, 2M, and 4M simulating the mufflers 1, 2, and 4, respectively. In FIG. 2, FIG. 4, and FIG. 7, darker portions indicate that the gas flow velocity is high, while lighter portions indicate that the gas flow velocity is low (gas is not flowing).

[0036] The basic configurations of the muffler 1 of Example 1, the muffler 2 of Example 2, and the muffler 3 of Example 3 respectively shown in FIG. 1, FIG. 3, and FIG. 5 are the same as that of the aforementioned muffler 4 of Comparative Example shown in FIG. 6. Thus, the portions of the mufflers 1, 2, and 3 corresponding to those of the muffler 4 are denoted by the same reference numerals.

[0037] The mufflers 1, 2, 3, and 4 each include the muffler body 10 in a box container-shape that introduces and discharges an exhaust gas from the stratified scavenging engine, and the inside of the muffler body 10 is hermetically partitioned by the partitioning wall plate 13 into the front chamber R1 and the rear chamber R2 on the front and rear sides.

[0038] An upper half portion of the front chamber R1 is provided with the introduction port 16 for introducing the exhaust gas from the exhaust port 9 provided in the cylinder 8 of the stratified scavenging engine. The partitioning wall plate 13 is disposed vertically to the direction in which the exhaust gas is introduced. A lower portion of the rear chamber R2 on the downstream side of the front chamber R1 is provided with a discharge port 17 for discharging the exhaust gas after being purified by the columnar catalyst 20.

[0039] The monolithic form columnar catalyst 20 for exhaust gas purification is securely attached to roughly a lower half portion of the partitioning wall plate 13, so as to extend over the front chamber R1 and the rear chamber R2, with its axis orthogonal to the partitioning wall plate 13.

[0040] The columnar catalyst 20 is an oxidation catalyst capable of oxidation combusting the THC such as uncombusted fuel components contained in the exhaust gas and includes the metallic or ceramic carrier 22 provided with the multiple cells 24 in a grid pattern, each cell 24 having the linear passage 24a that allows the front chamber R1 and the rear chamber R2 to communicate with each other. The inside (each cell 24) of the carrier 22 is coated with an oxidation catalyst material of a platinum group, such as platinum and rhodium, and the metallic cylindrical shell 23 is externally fitted and secured to the outer periphery of the carrier 22. It should be noted that the columnar catalyst 20 may be a redox catalyst, a three-way catalyst, or the like.

[0041] A catalyst attachment portion 14 having a circular insertion hole 14a for enabling the columnar catalyst 20 to be secured at any position in a direction orthogonal to the partitioning wall plate 13 (the axial direction of the catalyst 20) is provided in roughly a lower half portion of the partitioning wall plate 13. The columnar catalyst 20 is hermetically attached to the catalyst attachment portion 14 using a method of welding, adhesion, brazing, or the like.

[0042] The stratified scavenging engine that uses the muffler 1, 2, 3, or 4 has a displacement of around 30 cc (e.g., 20 to 40 cc, particularly around 28 to 32 cc), and the capacity of the front chamber R1 of each of the mufflers 1, 2, 3, and 4 is four to six times the displacement (see Patent Literature 3 for the details of this matter, if necessary).

[0043] Herein, as described above, the inventors of the present invention found that the phenomenon as described with reference to FIG. 6 and FIG. 7, in which the gas flow in the upper portion of the columnar catalyst 20 hitting against the partitioning wall plate 13 to be reversed bypasses a portion of a plurality of rows of cells 24 in the upper end portion (outer periphery portion) of the columnar catalyst 20, can be prevented by setting, within a predetermined range, at least one of the distance A from the introduction port 16 to the partitioning wall plate 13, the distance D from the front wall surface 11a of the front chamber R1 to the front end surface 20a of the columnar catalyst 20, or the distance T (the length of the catalyst

20 extending into the front chamber R1) from the partitioning wall plate 13 to the front end surface 20a of the columnar catalyst 20.

[0044] Specifically, FIG. 8 with the longitudinal axis and the lateral axis respectively representing the proportion of gas that does not pass through the catalyst 20 and the distance of the partitioning wall plate 13 from the reference position shows the proportions of gas that does not pass through the catalyst when the positions of the partitioning wall plate 13 and the columnar catalyst 20 are changed in the front-back direction.

[0045] The aforementioned reference position of the partitioning wall plate 13 is a position of the partitioning wall plate 13 in the front-back direction of the muffler 2 (FIG. 3) of Example 2, which is at the center in the front-back direction of the columnar catalyst 20. The muffler 4 of Comparative Example shown in FIG. 6 has the partitioning wall plate 13 at a position shifted by 7 mm from the reference position toward the introduction port 16 side (forward or toward the upstream side). The muffler 3 of Example 3 shown in FIG. 5 has the partitioning wall plate 13 at a position shifted by 3.5 mm from the reference position toward the introduction port 16 side (forward or toward the upstream side). Further, the muffler 1 of Example 1 shown in FIG. 1 has the partitioning wall plate 13 at a position shifted by 5 mm rearward or toward the downstream side from the reference position.

[0046] The columnar catalyst 20 used in each of the mufflers 1, 2, 3, and 4 is the aforementioned monolithic form catalyst having the diameter C of about 30 mm and the length L of about 21 mm.

[0047] The aforementioned proportion of gas that does not pass through the catalyst 20 is the proportion of a portion where the gas does not flow in the catalyst 20, and indicates herein the proportion obtained by dividing the number of cells where the gas does not flow as seen in the central cross section by the total number of cells.

[0048] In the mufflers 1, 2, 3, and 4, the position of the columnar catalyst 20 relative to the entire muffler body is the same (fixed at D = 14.5 mm), and only the position of the partitioning wall plate 13 in the front-back direction is differentiated. It should be noted that the dots plotted on the line in FIG. 8 show the proportions of the gas that does not pass through the columnar catalyst 20 in the cases where the columnar catalyst 20 is at a fixed position and only the position of the partitioning wall plate 13 in the front-back direction is differentiated. Further, the dots plotted with numbers attached in FIG. 8 indicate that the position of the columnar catalyst 20 in the front-back direction as well as the position of the partitioning wall plate 13 in the front-back direction is differentiated. The numbers in FIG. 8 basically correspond to those in FIG. 9.

[0049] In the muffler 4 of Comparative Example shown in FIG. 6 having the partitioning wall plate 13 at a position shifted by 7 mm (i.e., T = 3.5 mm) from the reference position toward the introduction port 16 side (forward or toward the upstream side), as seen from the gas flow and gas flow velocity within the muffler (A) and the columnar catalyst (B) that are visualized in grayscale of the analysis model 4M of FIG. 7, the reversed gas flow in the upper portion of the columnar catalyst 20 bypasses a portion of a plurality of rows of cells 24 in the upper end portion of the columnar catalyst 20, and thus, the gas scarcely flows in the portion (portion in white) of the plurality of rows of cells 24, 24, ... that the gas flow bypasses. Therefore, the proportion of the gas that does not pass through the catalyst 20 is around 20% and in addition, the difference in the gas flow velocity within the catalyst 20 is large. Thus, the muffler 4 is unusable.

[0050] Further, in the muffler 3 of Example 3 shown in FIG. 5 having the partitioning wall plate 13 at a position shifted by 3.5 mm (i.e., T = 7.0 mm) from the reference position toward the introduction port 16 side (forward or toward the upstream side), the analysis model of which is not illustrated, the reversed gas flow in the upper portion of the columnar catalyst 20 bypasses a portion of nearly one row of the cell 24 in the upper end portion of the columnar catalyst 20, but the proportion of the gas that does not pass through the catalyst 20 is around 14%, which is within the acceptable range (usable).

[0051] Furthermore, in the muffler 2 of Example 2 shown in FIG. 3 having the partitioning wall plate 13 at the reference position (i.e., T = 10.5 mm), as seen from the gas flow and gas flow velocity within the muffler (A) and the columnar catalyst (B) that are visualized in grayscale of the analysis model 2M of FIG. 4 that simulates the muffler 2, the reversed gas flow in the upper portion of the columnar catalyst 20 bypasses a portion of little less than one row of the cell 24 in the upper end portion of the columnar catalyst 20, but the proportion of the gas that does not pass through the catalyst 20 is little more than 6%. Thus, the muffler 2 is a good product.

[0052] In addition, in the muffler 1 of Example 1 shown in FIG. 1 having the partitioning wall plate 13 at a position shifted by 5 mm (i.e., T = 15.5 mm) from the reference position rearward or toward the downstream side, as seen from the gas flow and gas flow velocity within the muffler (A) and the columnar catalyst (B) that are visualized in grayscale of the analysis model 1M of FIG. 2 that simulates the muffler 1, part of the gas flow hitting against the partitioning wall plate 13 to be reversed also enters the cells 24 in the upper end portion of the columnar catalyst 20 while being guided to the outer periphery surface (on the front chamber R1 side or introduction port 16 side) of the cylindrical shell 23 of the columnar catalyst 20. Therefore, the proportion of the gas that does not pass through the catalyst 20 is almost 0% and in addition, the difference in the gas flow velocity within the catalyst 20 is small. Thus, the muffler 1 is an excellent product.

[0053] It should be noted that the proportion of the gas that does not pass through the catalyst 20 is preferably less than 7% (Examples 1 and 2), but the proportion in a range of 7 to 14% (Example 3) is within the acceptable range (usable), and those exceeding 14% are unacceptable.

[0054] It should be noted that it is clear that for the

distance H from the lower end of the introduction port 16 to the upper end of the columnar catalyst 20, 9 mm or greater is preferably secured.

[0055] FIG. 9 is a table showing the proportions of gas that does not pass through the catalyst 20 when the dimensional parameters of the mufflers, which are the distance A from the introduction port 16 to the partitioning wall plate 13 and the distance D from the front wall surface 11a of the front chamber R1 to the front end surface 20a of the catalyst 20, are changed. As mentioned above, the numbers in FIG. 9 correspond to those in FIG. 8.

[0056] FIG. 9 indicates sample No. 17 (A = 18.0 mm, D = 2.0 mm) as unusable. This is because the distance D from the front wall surface 11a of the front chamber R1 to the front end surface 20a of the catalyst 20 is extremely short, which makes it difficult for the gas to flow in the vicinity of the outer periphery of the catalyst 20 and causes the gas to intensively flow in the center portion of the catalyst 20, thereby creating a nonuniform gas flow within the catalyst 20 overall. Therefore, it is clear that for the distance D from the front wall surface 11a of the front chamber R1 to the front end surface 20a of the catalyst 20,5 mm or greater needs to be secured (see also sample Nos. 13 and 18 which are usable products).

[0057] Further, FIG. 10 is a graph with the longitudinal axis representing the length T (A-D) of the catalyst 20 extending into the front chamber R1 and with the lateral axis representing the distance A from the introduction port 16 to the partitioning wall plate 13, the graph showing regions classified by three levels of proportions of gas that does not pass through the catalyst 20.

[0058] As described above, since for the length T (A-D) of the catalyst 20 extending into the front chamber R1, 7 mm or greater needs to be secured, the range of the distance A from the introduction port 16 to the partitioning wall plate 13 that is preferred under this condition is 25 mm or greater. However, as long as the length T (A-D) of the catalyst 20 extending into the front chamber R1 is secured to some extent, even with the distance A from the introduction port 16 to the partitioning wall plate 13 less than 25 mm (e.g., 21.5 mm or greater as in Example 3), the acceptable range of 7 to 14% of the proportion of the gas that does not pass through the catalyst 20 can be satisfied.

[0059] The results of the experiments for analysis or the like shown in FIG. 8, FIG. 9, and FIG. 10 above reveal that in the case of the aforementioned existing monolithic product having the engine displacement of around 30 cc (e.g., 20 to 40 cc, particularly around 28 to 32 cc) and the columnar catalyst 20 with the diameter C of 25 to 50 mm and the length L of 15 to 35 mm, it is preferable that the distance A from the introduction port 16 to the partitioning wall plate 13 is set to be within a range of 21.5 mm or greater, the distance D from the front wall surface 11a of the front chamber R1 to the front end surface 20a of the columnar catalyst 20 is set to be within a range of 5 mm or greater, the distance T from the partitioning wall plate 13 to the front end surface 20a of the columnar catalyst 20 is set to be within a range of 7 mm or greater, and the distance H from the lower end of the introduction port 16 to the upper end of the columnar catalyst 20 is set to be within a range of 9 mm or greater. Further, considering the overall dimensions of the muffler or the like, it is preferable that the distance A from the introduction port 16 to the partitioning wall plate 13 is set to be within a range of 25 to 30 mm, the distance D from the front wall surface 11a of the front chamber R1 to the front end surface 20a of the columnar catalyst 20 is set to be within a range of 5 to 20 mm, the distance T from the partitioning wall plate 13 to the front end surface 20a of the columnar catalyst 20 is set to be within a range of 7 to 16 mm, and the distance H from the lower end of the introduction port 16 to the upper end of the columnar catalyst 20 is set to be within a range of 9 to 20 mm. In this manner, the phenomenon in which the gas flow in the upper portion of the columnar catalyst 20 hitting intensely against the partitioning wall plate 13 to be reversed bypasses a portion of a plurality of rows of cells in the upper end portion (outer periphery portion) of the columnar catalyst 20 can be prevented, and the proportion of the gas that does not pass through the catalyst 20 can be reduced to around 14% or lower.

[0060] As is appreciated from the above description, in the muffler 1 for a stratified scavenging engine of the present embodiment, without making any changes to the outside dimensions of the muffler body, the position of the introduction port, the diameter and length of the columnar catalyst, and the position of the columnar catalyst in the height direction in the muffler body of an existing muffler, at least one of the distance A from the introduction port 16 to the partitioning wall plate 13, the distance D from the front wall surface 11a of the front chamber R1 to the front end surface 20a of the columnar catalyst 20, or the distance T (the length of the catalyst 20 extending into the front chamber R1) from the partitioning wall plate 13 to the front end surface 20a of the columnar catalyst 20 is set to be within a predetermined range, so as to prevent the exhaust gas introduced into the front chamber R1 through the introduction port 16 and hitting against the partitioning wall plate 13 to be reversed from bypassing the cells 24 in the upper end portion of the columnar catalyst 20 as much as possible. In this manner, specifying only the peripheral structure of the columnar catalyst enables an efficient reaction of the catalyst without enlarging the muffler and can also contribute to downsizing the entire working machine including the stratified scavenging engine.

[0061] Therefore, part of the gas flow hitting against the partitioning wall plate 13 to be reversed also enters the cells 24 in the upper end portion of the columnar catalyst 20 while being guided to the outer periphery surface of the cylindrical shell 23 provided in the outer periphery of the columnar catalyst 20. In this manner, the number of cells where the exhaust gas does not flow in the columnar catalyst 20 can be reduced as much as possible to create a uniform exhaust gas flow in the co-

lumnar catalyst 20. As a result, a desired exhaust gas purification rate can be obtained and the THC emissions can be effectively curbed.

[0062] Moreover, the muffler 1 for a stratified scavenging engine of the present embodiment is cost effective, since an existing muffler part including the columnar catalyst 20 can be used by making a simple adjustment to, for example, the distance T from the partitioning wall plate 13 to the front end surface 20a of the columnar catalyst 20, that is, the length of the catalyst 20 extending into the front chamber R1 (the position of the catalyst 20 in the axial direction relative to the partitioning wall plate 13) on the basis of the results of experiments for analysis conducted in advance using a computer or the like, so that the functional effects as described above can be obtained.

[0063] It should be noted that although in the aforementioned embodiments, the mufflers for a stratified scavenging engine having a displacement of around 30 cc have been described, it is obvious that the muffler according to the present invention is also applicable to stratified scavenging engines other than those having a displacement of around 30 cc.

DESCRIPTION OF SYMBOLS

[0064]

1, 2, 3, 4	Muffler for stratified scavenging engine
8	Cylinder
9	Exhaust port
10	Muffler body
11	Front chamber panel
11a	Front wall surface
12	Rear chamber panel
13	Partitioning wall plate
14	Catalyst attachment portion
14a	Circular insertion hole
16	Introduction port
17	Discharge port
20	Columnar catalyst
20a	Front end surface
22	Carrier
23	Cylindrical shell
24	Cell
24a	Linear passage
R1	Front chamber
R2	Rear chamber
A	Distance from introduction port to partitioning wall plate
D	Distance from front wall surface of front chamber to front end surface of columnar catalyst
T	Distance from partitioning wall plate to front end surface of columnar catalyst
H	Distance from lower end of introduction port to upper end of columnar catalyst

Claims

1. A muffler for a stratified scavenging engine, comprising:

   a muffler body that introduces and discharges an exhaust gas from a stratified scavenging engine;
   a partitioning wall plate disposed inside the muffler body vertically to a direction in which the exhaust gas is introduced, the partitioning wall plate hermetically partitioning the muffler body into a front chamber and a rear chamber on a downstream side of the front chamber, an upper half portion of the front chamber provided with an introduction port for introducing the exhaust gas; and
   a columnar catalyst for exhaust gas purification attached to roughly a lower half portion of the partitioning wall plate so as to extend over the front chamber and the rear chamber, with an axis of the columnar catalyst orthogonal to the partitioning wall plate,
   wherein
   the columnar catalyst is a monolithic form catalyst provided with multiple cells in a grid pattern, each cell having a linear passage that allows the front chamber and the rear chamber to communicate with each other, and
   at least one of a distance A from the introduction port to the partitioning wall plate, a distance D from a front wall surface of the front chamber to a front end surface of the columnar catalyst, or a distance T from the partitioning wall plate to the front end surface of the columnar catalyst is set to be within a predetermined range so as to prevent a gas flow introduced into the front chamber through the introduction port and hitting against the partitioning wall plate to be reversed from bypassing the cells in an upper end portion of the columnar catalyst as much as possible.

2. The muffler for a stratified scavenging engine according to claim 1, wherein
   part of the gas flow reversed also enters the cells in the upper end portion of the columnar catalyst while being guided to an outer periphery surface of a cylindrical shell provided in an outer periphery of the columnar catalyst.

3. The muffler for a stratified scavenging engine according to claim 1 or 2, wherein
   the columnar catalyst is an oxidation catalyst, a redox catalyst, or a three-way catalyst capable of oxidation combusting at least an uncombusted fuel component contained in the exhaust gas.

4. The muffler for a stratified scavenging engine according to any one of claims 1 to 3, wherein
a catalyst attachment portion is provided in roughly the lower half portion of the partitioning wall plate, the catalyst attachment portion having a circular insertion hole for enabling the columnar catalyst to be secured at any position in a direction orthogonal to the partitioning wall plate.

5. The muffler for a stratified scavenging engine according to claim 4, wherein
the columnar catalyst is hermetically attached to the catalyst attachment portion through welding.

6. The muffler for a stratified scavenging engine according to any one of claims 1 to 5, wherein
a capacity of the front chamber is set to four to six times a displacement of the stratified scavenging engine.

7. The muffler for a stratified scavenging engine according to any one of claims 1 to 6, wherein
the distance A from the introduction port to the partitioning wall plate is set to be within a range of 21.5 mm or greater, the distance D from the front wall surface of the front chamber to the front end surface of the columnar catalyst is set to be within a range of 5 mm or greater, the distance T from the partitioning wall plate to the front end surface of the columnar catalyst is set to be within a range of 7 mm or greater, and a distance H from a lower end of the introduction port to an upper end of the columnar catalyst is set to be within a range of 9 mm or greater.

8. The muffler for a stratified scavenging engine according to claim 7, wherein
the distance A from the introduction port to the partitioning wall plate is set to be within a range of 25 to 30 mm, the distance D from the front wall surface of the front chamber to the front end surface of the columnar catalyst is set to be within a range of 5 to 20 mm, the distance T from the partitioning wall plate to the front end surface of the columnar catalyst is set to be within a range of 7 to 16 mm, and the distance H from the lower end of the introduction port to the upper end of the columnar catalyst is set to be within a range of 9 to 20 mm.

9. The muffler for a stratified scavenging engine according to any one of claims 1 to 8, wherein
a displacement of the stratified scavenging engine is within a range of 20 to 40 cc and a diameter C and a length L of the columnar catalyst are within a range of 25 to 50 mm and a range of 15 to 35 mm, respectively.

Fig. 1

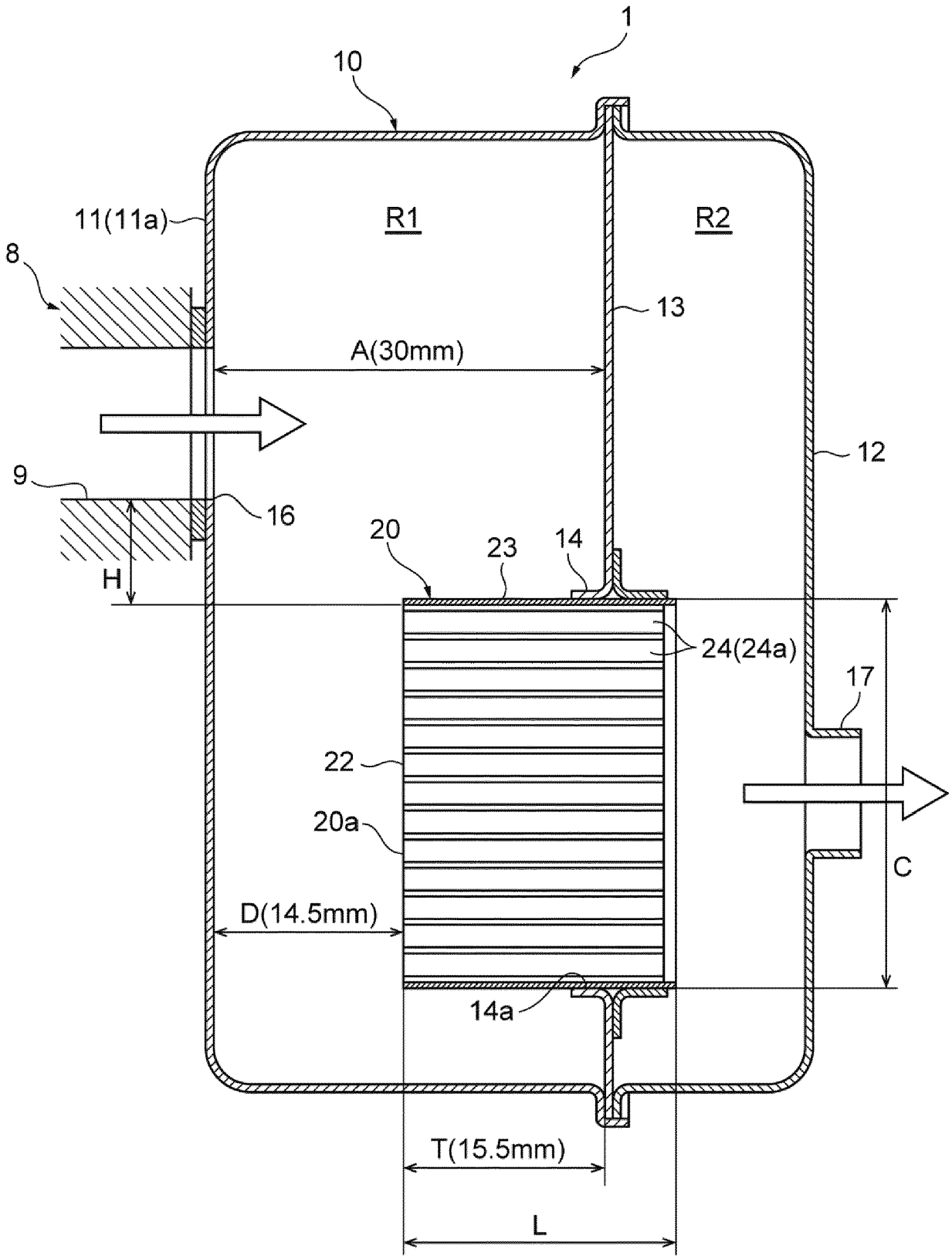

1
10
11(11a)
R1
R2
8
13
A(30mm)
12
9
16
20
23
14
H
24(24a)
17
22
20a
C
D(14.5mm)
14a
T(15.5mm)
L

Fig. 2

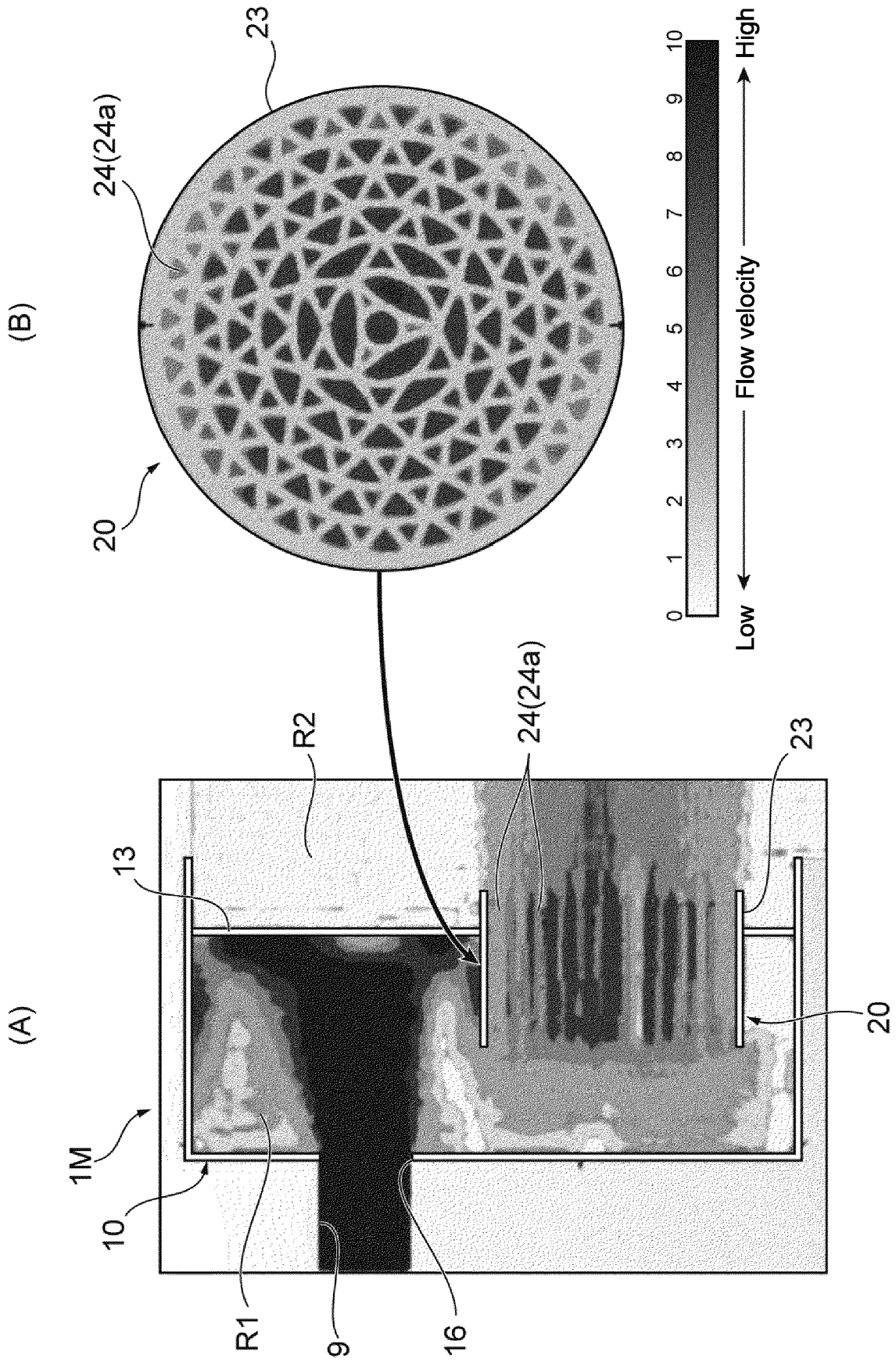

(A)
(B)
1M
10
13
R1
R2
9
16
20
23
24(24a)
Flow velocity
High
Low
0
1
2
3
4
5
6
7
8
9
10

Fig. 3

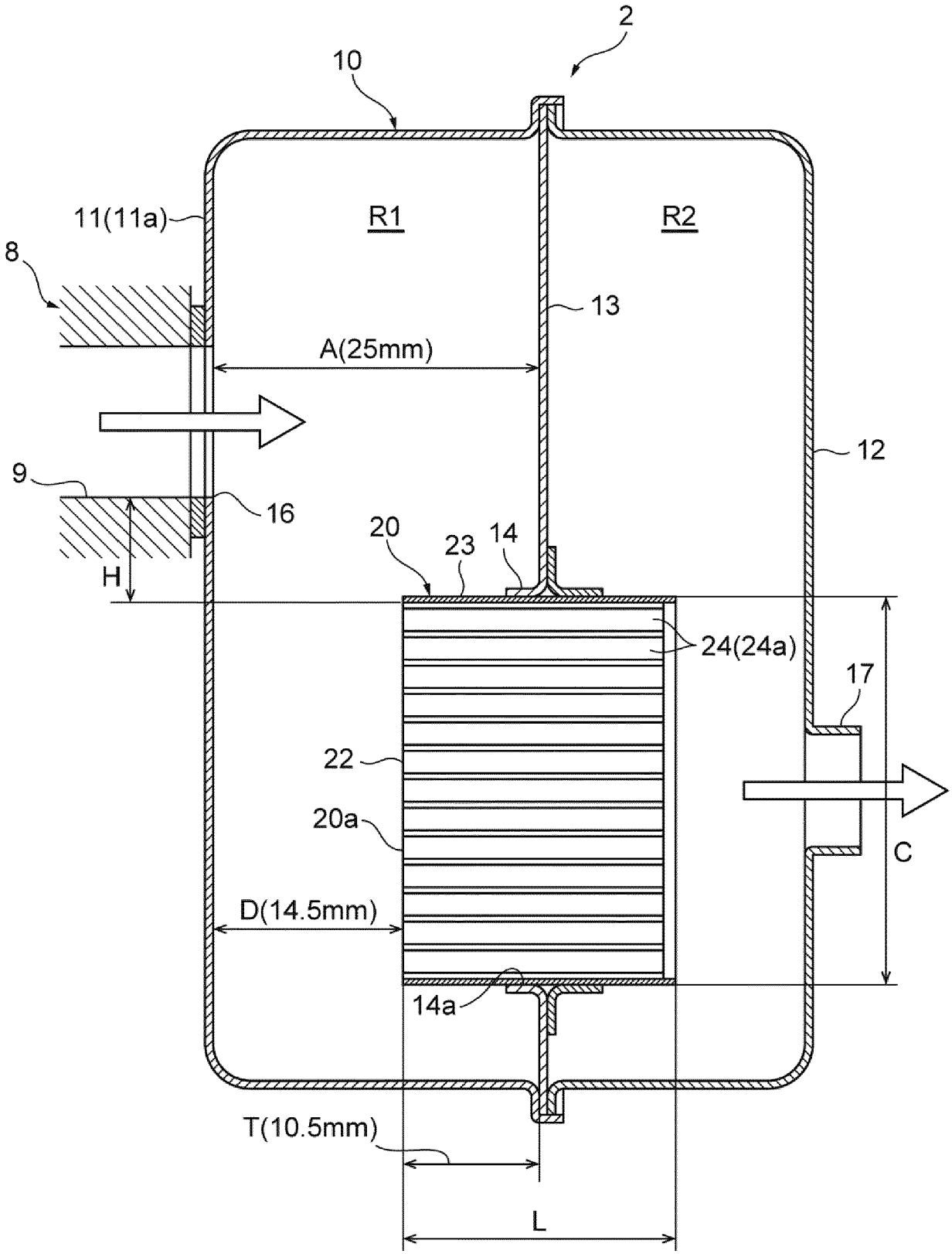

2
10
11(11a)
R1
R2
8
13
A(25mm)
12
9
16
20
23
14
H
24(24a)
17
22
20a
C
D(14.5mm)
14a
T(10.5mm)
L

Fig. 4

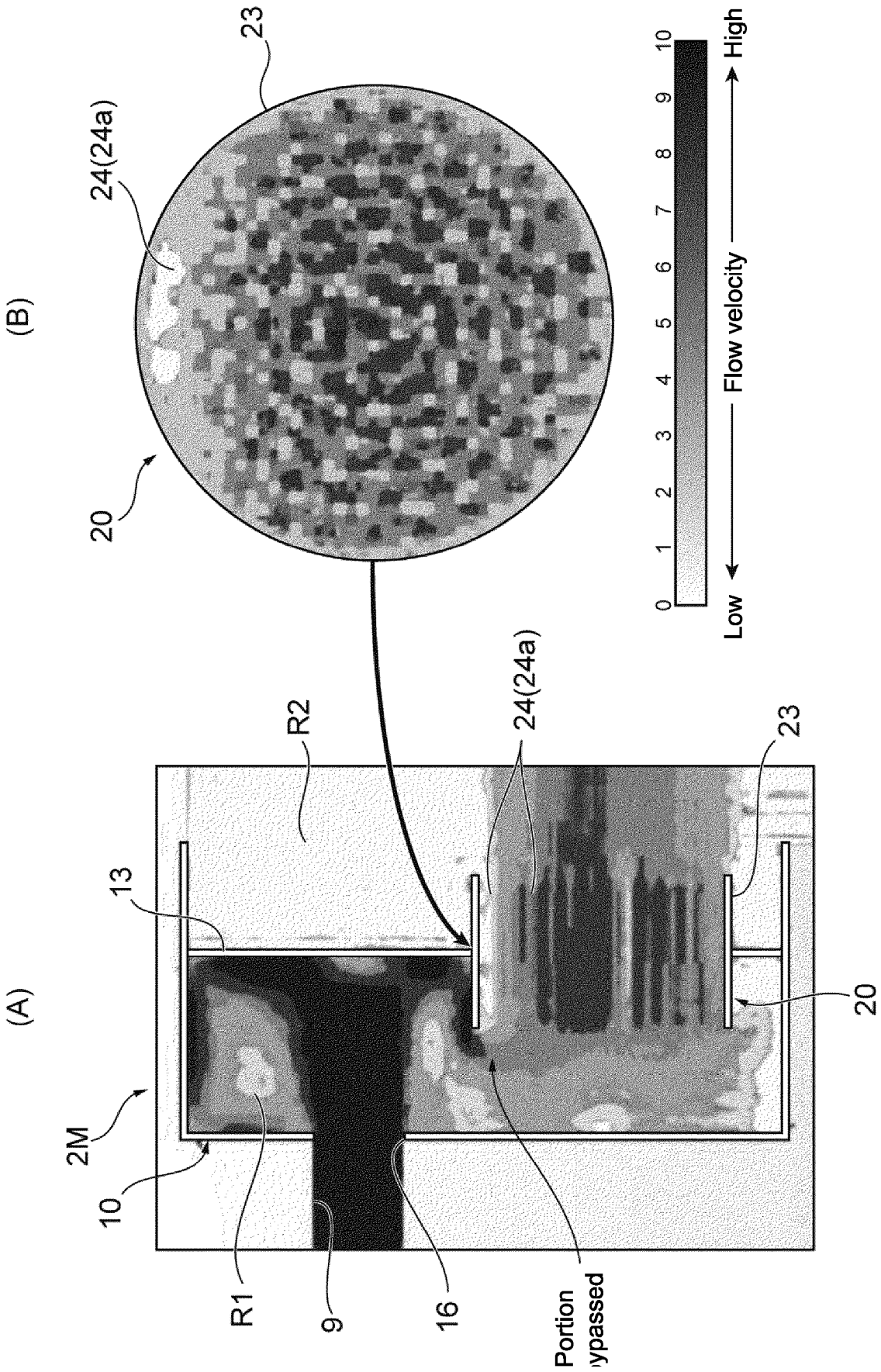

(A)
(B)
2M
10
13
R1
9
16
R2
24(24a)
23
20
Portion bypassed
0
1
2
3
4
5
6
7
8
9
10
Low
Flow velocity
High

Fig. 5

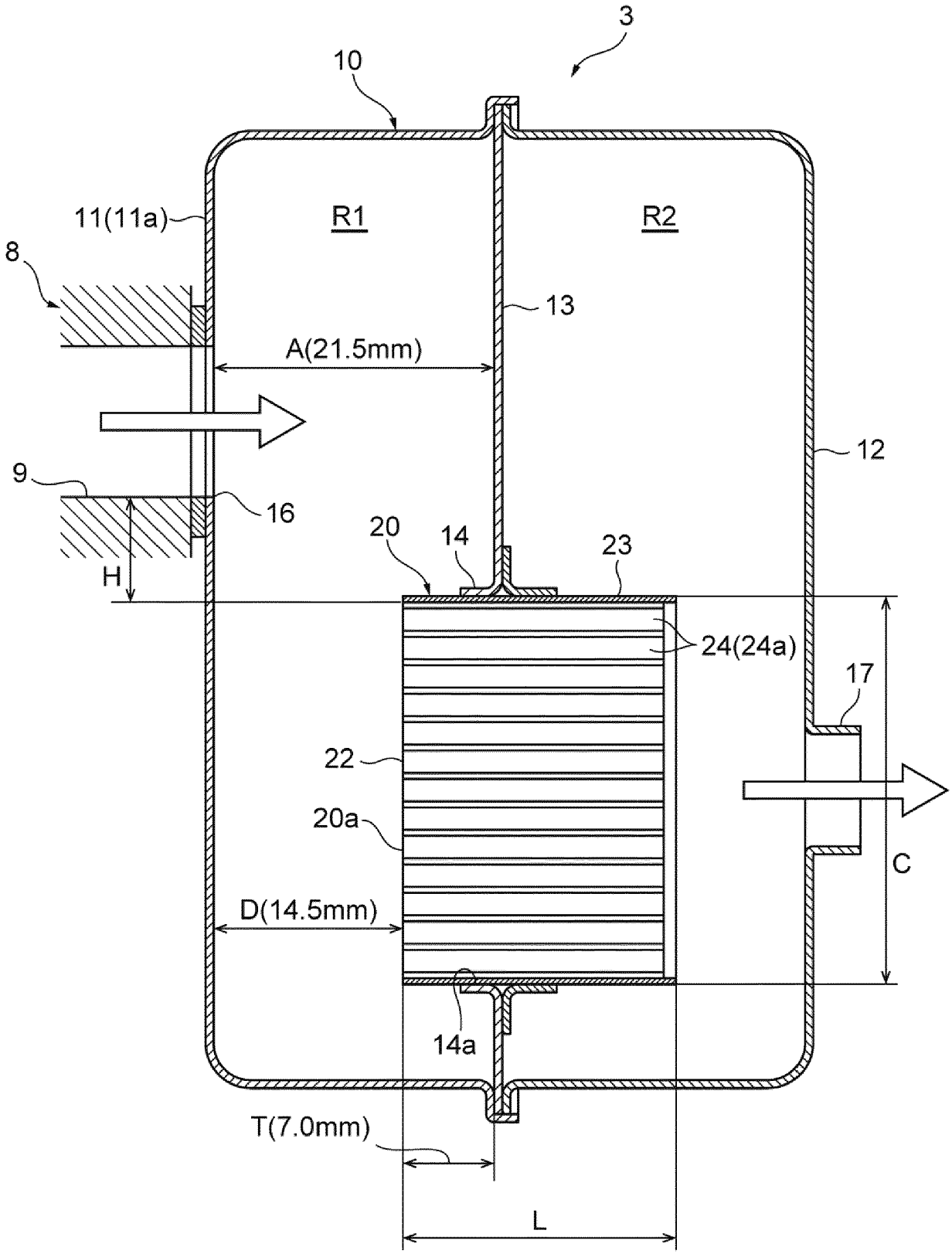

3
10
11(11a)
R1
R2
8
13
A(21.5mm)
12
9
16
20
14
23
H
24(24a)
17
22
20a
C
D(14.5mm)
14a
T(7.0mm)
L

Fig. 6

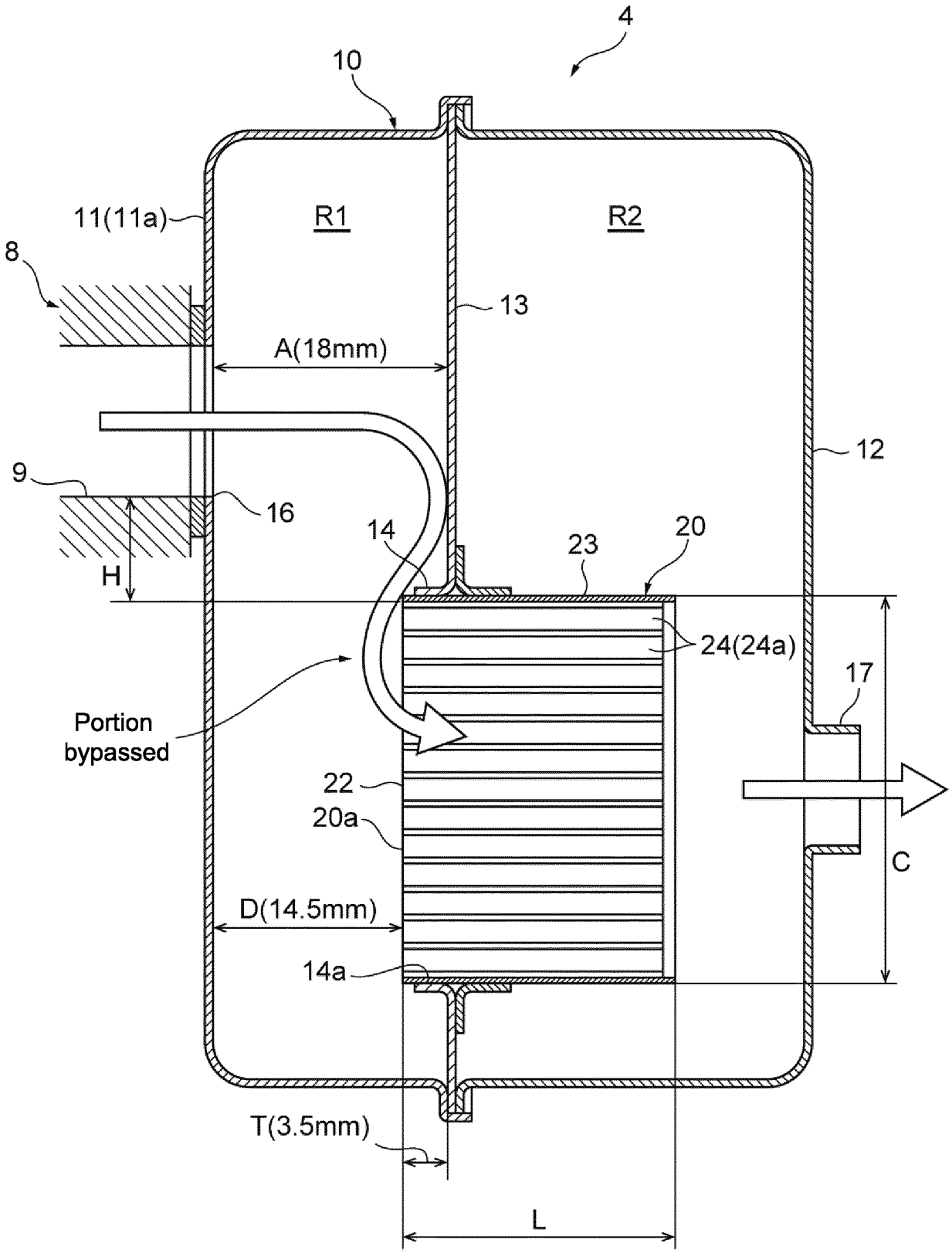

4
10
11(11a)
R1
R2
8
13
A(18mm)
12
9
16
14
23
20
H
24(24a)
17
Portion
bypassed
22
20a
C
D(14.5mm)
14a
T(3.5mm)
L

Fig. 7

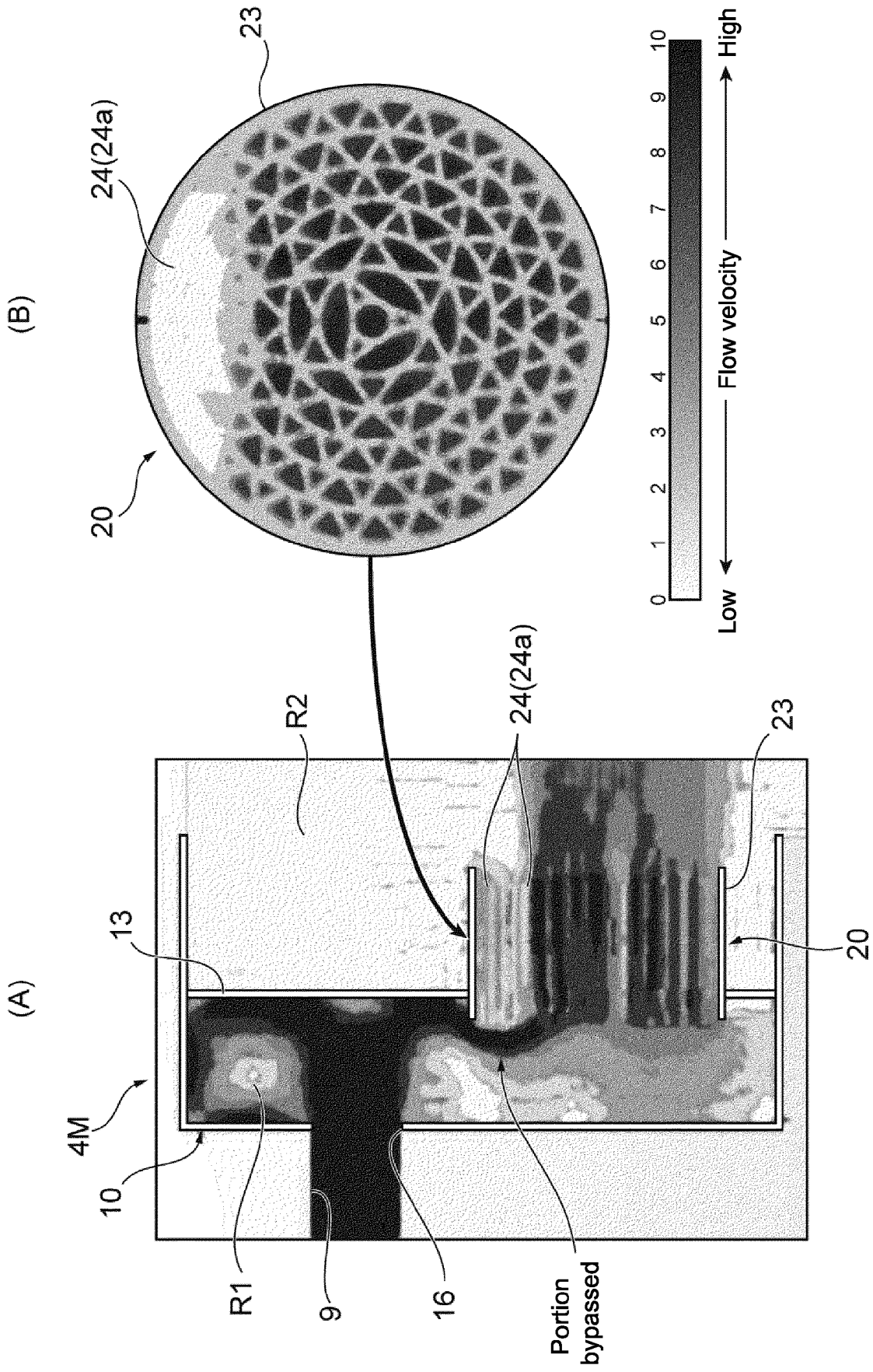

(A)
(B)
4M
10
13
R1
9
16
R2
24(24a)
23
20
Portion bypassed
Low
Flow velocity
High
0
1
2
3
4
5
6
7
8
9
10

Fig. 8

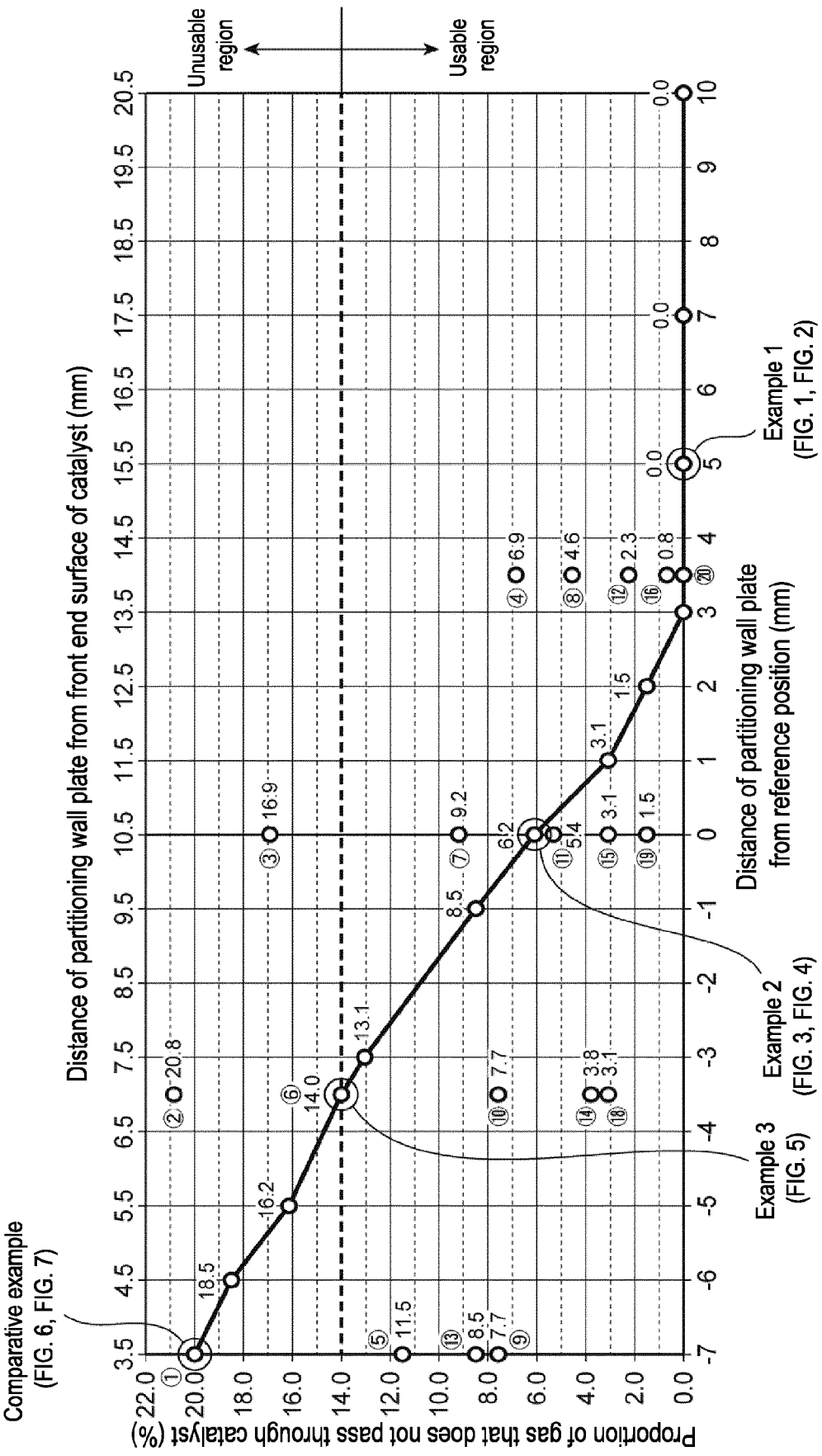
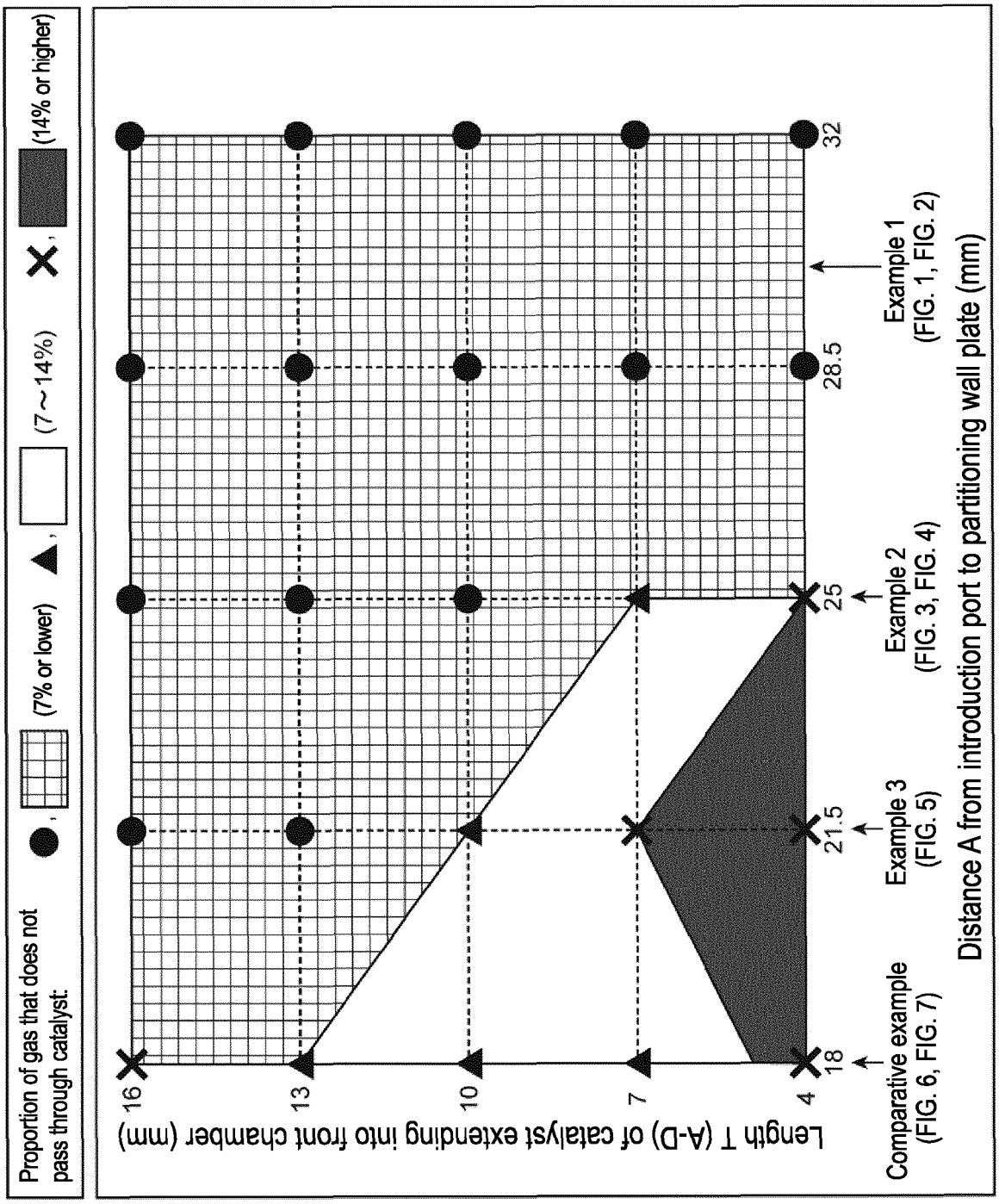

Unusable region
Usable region
Distance of partitioning wall plate from front end surface of catalyst (mm)
Proportion of gas that does not pass through catalyst (%)
Distance of partitioning wall plate from reference position (mm)
Comparative example (FIG. 6, FIG. 7)
Example 1 (FIG. 1, FIG. 2)
Example 2 (FIG. 3, FIG. 4)
Example 3 (FIG. 5)

Fig. 9

No.	Dimensional parameters of muffler			Proportion [—]
	A—D	A	D	
	[mm]	[mm]	[mm]	
①	4.0	18.0	14.0	20.0
②	4.0	21.5	17.5	20.8
③	4.0	25.0	21.0	16.9
④	4.0	28.5	24.5	6.9
—	4.0	32.0	28.0	6.2
⑤	7.0	18.0	11.0	11.5
⑥	7.0	21.5	14.5	14.0
⑦	7.0	25.0	18.0	9.2
⑧	7.0	28.5	21.5	4.6
—	7.0	32.0	25.0	3.8
⑨	10.0	18.0	8.0	7.7
⑩	10.0	21.5	11.5	7.7
⑪	10.0	25.0	15.0	5.4
⑫	10.0	28.5	18.5	2.3
—	10.0	32.0	22.0	2.3
⑬	13.0	18.0	5.0	8.5
⑭	13.0	21.5	8.5	3.8
⑮	13.0	25.0	12.0	3.1
⑯	13.0	28.5	15.5	0.8
—	13.0	32.0	19.0	0.0
⑰	16.0	18.0	2.0	25.4
⑱	16.0	21.5	5.5	3.1
⑲	16.0	25.0	9.0	1.5
⑳	16.0	28.5	12.5	0.0
—	16.0	32.0	16.0	0.0

Fig. 10


Proportion of gas that does not pass through catalyst:
(7% or lower)
(7～14%)
(14% or higher)
Length T (A-D) of catalyst extending into front chamber (mm)
16
13
10
7
4
18
21.5
25
28.5
32
Comparative example (FIG. 6, FIG. 7)
Example 3 (FIG. 5)
Example 2 (FIG. 3, FIG. 4)
Example 1 (FIG. 1, FIG. 2)
Distance A from introduction port to partitioning wall plate (mm)

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 6785

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	US 2003/085072 A1 (MUKAIDA HIDENORI [JP]) 8 May 2003 (2003-05-08)	1-5,7-9	INV. F01N3/28
A	* paragraphs [0004] - [0006]; figure 1 * * paragraphs [0042], [0043]; figure 3 *	6	F01N13/00 F01N1/08
X,D	JP 2020 063700 A (YAMABIKO CORP) 23 April 2020 (2020-04-23) * paragraphs [0012] - [0019]; figures 1-3 *	1-9	
X	US 6 164 066 A (SAKAGUCHI YUKIO [JP] ET AL) 26 December 2000 (2000-12-26) * column 4, line 30 - column 5, line 50; figure 1 * * column 8, line 16 - line 41; figure 7 *	1-9	

TECHNICAL FIELDS SEARCHED (IPC)
F01N
F02B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 August 2022	Kolland, Ulrich

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EPO FORM 1503 03.82 (P04C01)

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29-08-2022

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		JP 3930961 B2	13-06-2007
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- US 6647713 B **[0009]**
- JP 2020063700 A **[0009]**