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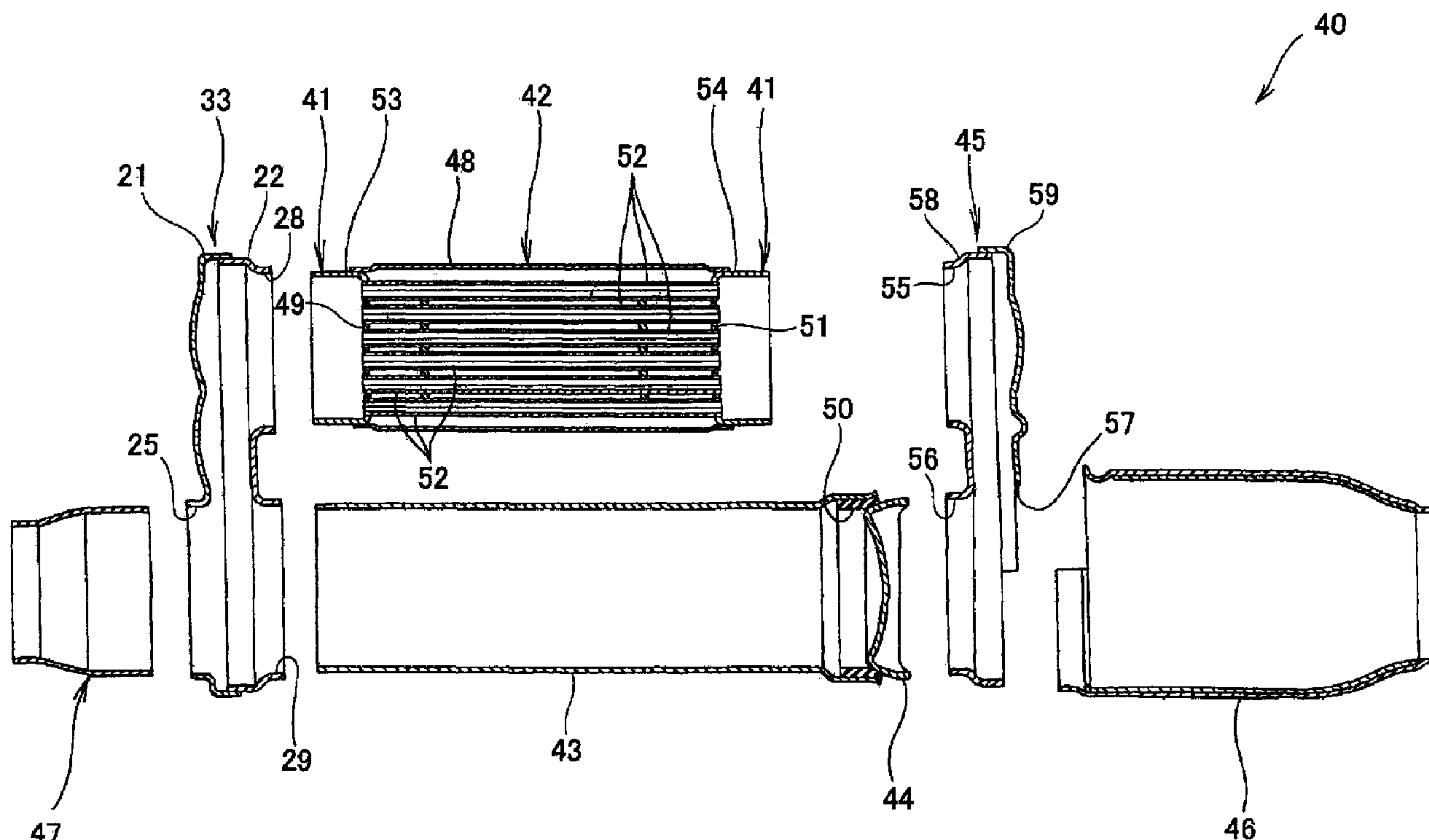
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(54) Titre : DISPOSITIF DE RECUPERATION DE LA CHALEUR DE GAZ D'ECHAPPEMENT

(54) Title: EXHAUST HEAT RECOVERY DEVICE



(57) Abrégé/Abstract:

An exhaust heat recovery device comprises: a heat exchanger for recovering heat from exhaust gas; a second flow channel for circulating the exhaust gas during exhaust heat non-recovery; a branching member for connecting an inlet of the heat exchanger



(57) **Abrégé(suite)/Abstract(continued):**

and an inlet of the second flow channel; a merging member for connecting an outlet of the heat exchanger and an outlet of the second flow channel; a valve for blocking the outlet of the second flow channel; and a valve chamber for housing the valve. The branching member is comprised of a single chamber formed by joining together a first chamber half in which one inlet is provided, the first chamber half being draw- molded from a blank, and a second chamber half in which two outlets are provided, the second chamber half being draw-molded from a blank.

ABSTRACT OF THE DISCLOSURE

An exhaust heat recovery device comprises: a heat exchanger for recovering heat from exhaust gas; a second flow channel for circulating the exhaust gas during exhaust heat non-recovery; a branching member for connecting an inlet of the heat exchanger and an inlet of the second flow channel; a merging member for connecting an outlet of the heat exchanger and an outlet of the second flow channel; a valve for blocking the outlet of the second flow channel; and a valve chamber for housing the valve. The branching member is comprised of a single chamber formed by joining together a first chamber half in which one inlet is provided, the first chamber half being draw-molded from a blank, and a second chamber half in which two outlets are provided, the second chamber half being draw-molded from a blank.

EXHAUST HEAT RECOVERY DEVICE

FIELD OF THE INVENTION

The present invention relates to an exhaust heat recovery device for recovering
5 heat from an exhaust emission or gas.

BACKGROUND OF THE INVENTION

An internal combustion engine is designed to burn fuel to generate heat energy
and to obtain power by converting the generated heat energy into kinetic energy. Not
all of the heat energy can be converted to kinetic energy, because a portion of the heat
10 energy is discharged into the atmosphere in the form of exhaust gas. The loss of heat
energy through the exhaust gas reduces the efficiency of the internal combustion
engine. A technique is known in which an exhaust heat recovery device is attached to
the exhaust pipe, and a portion of the heat energy is recovered from the exhaust gas by
the exhaust heat recovery device.

15 Japanese Patent Application Laid-Open Publication No. 2009-30569, for
example, discloses an exhaust heat recovery device. The structure of this exhaust
heat recovery device is described with reference to FIG. 13 hereof.

As shown in FIG. 13, the exhaust heat recovery device 100 is composed of a
bypass flow channel 101 for circulating exhaust gas, the bypass flow channel being
20 connected to an exhaust pipe extending from an internal combustion engine; a
branching channel 103 branched at a right angle to the axis of the bypass flow channel
101 from the vicinity of an inlet 102 of the bypass flow channel 101; a valve 105
capable of opening and closing, for blocking an outlet 104 of the bypass flow channel
101; a valve shaft 106 for rotating the valve 105; a curved pipe 107 which extends from
25 the valve 105; a case 108 for housing the bypass flow channel 101, the valve 105, and

the curved pipe 107 at once; an exhaust heat recovery flow channel 111 for circulating the exhaust gas fed from the branching channel 103, the exhaust heat recovery flow channel being formed in the case 108; and a heat exchanger 112 which fits in the exhaust heat recovery flow channel 111. The bypass flow channel 101 is a flow
5 channel for bypassing the heat exchanger 112.

The medium of the high-temperature side of the heat exchanger 112 is the exhaust gas, and the medium of the low-temperature side is a coolant of the internal combustion engine.

The valve shaft 106 for supporting the valve 105 is urged toward the valve-
10 closing side by a torsion spring. When the flow rate of exhaust gas through the bypass flow channel 101 is high, the gas pressure overcomes the urging force of the torsion spring. As a result, the valve is opened. When the flow rate of exhaust gas is low, the valve is closed by the action of the torsion spring.

The valve shaft 106 is also rotated by a thermo-actuator via the torsion spring.
15 The coolant for cooling the internal combustion engine is passed through the thermo-actuator. When the coolant is at a high temperature, the valve shaft 106 is rotated toward the valve-open side by the thermo-actuator, and when the coolant is at a low temperature, the valve shaft 106 is rotated toward the valve-closed side.

The coolant is at a low temperature when the internal combustion engine is
20 started. The flow rate of exhaust gas is low during idling. The valve is closed under these conditions. Exhaust gas flows to the exhaust heat recovery flow channel 111 without flowing to the bypass flow channel 101. Heat is recovered by the heat exchanger 112, and the coolant is heated.

When the flow rate of exhaust gas is high even at startup of the internal
25 combustion engine, the valve opens and the exhaust gas flows to the bypass flow

channel 101. The bypass flow channel 101 has minimal flow channel resistance, and is therefore capable of circulating a large amount of exhaust gas.

The coolant reaches a high temperature once operation has continued for a certain amount of time. The valve is opened by the action of the thermo-actuator, and
5 the exhaust gas flows to the bypass flow channel 101. The reason for this is that there is no need for the coolant to be warmed by the heat exchanger 112 when the coolant is at a high temperature.

The case 108 is formed by welding together two case halves that are divided in the front-back direction of the drawing. Before welding, the bypass flow channel 101,
10 the valve 105, the valve shaft 106, and the heat exchanger 112 are placed in a case half. A first seal 113 is wrapped around the branching channel 103, and a second seal 114 is wrapped around the bypass flow channel 101. The other case half is then placed over the first case half, and the case halves are welded together.

Leakage and backflow of exhaust gas are prevented by the first seal 113 and/or
15 the second seal 114.

The first seal 113 and/or the second seal 114 cannot be replaced after the case halves are welded together. However, the first seal 113 and/or the second seal 114 become worn over the course of operation. As wear progresses, the sealing ability of the seals decreases, and backflow of exhaust gas occurs. Assembly is also made
20 inconvenient by the labor of packing the bypass flow channel 101, heat exchanger 112, and other components in the case halves and then welding the case halves. As a result, the cost of the exhaust heat recovery device increases, and the use of exhaust heat recovery devices is less easily adopted.

In order to promote the use of exhaust heat recovery devices, there is a need for
25 an exhaust heat recovery device that is easily assembled.

When the exhaust heat recovery device 100 is mounted in a vehicle having significant space limitations, a curved pipe 115 is frequently connected to the inlet of the bypass flow channel 101. The use of a curved pipe 115 enables the duct length to be maintained in a limited space. When a curved pipe 115 is used, a portion of the exhaust gas impinges on the inside surface of the bypass flow channel 101, as indicated by the arrow (1) in FIG. 13. This impingement causes the flow to become disordered, and there is a risk of inability to maintain the flow rate of the exhaust gas.

There is therefore a need for an exhaust heat recovery device in which a smooth flow of exhaust gas is maintained even when a curved pipe is connected to the inlet.

SUMMARY

It is desirable to provide a structure for an exhaust heat recovery device that is easy to assemble.

It is also desirable to provide an exhaust heat recovery device in which a smooth flow of exhaust gas is maintained even when a curved pipe is connected to an inlet.

According to an aspect of the present invention, there is provided an exhaust heat recovery device which comprises: a chamber-shaped branching member having one inlet for introducing exhaust gas and two outlets for discharging the exhaust gas; a first flow channel, extending from one of the two outlets, for circulating the exhaust gas; a heat exchanger, provided to the first flow channel, for recovering potential heat of the exhaust gas; a second flow channel, extending from other one of the two outlets, for circulating the exhaust gas while bypassing the heat exchanger; and a valve chamber for housing a valve designed to open and closing the outlet of the second flow channel, wherein the branching member comprises a single chamber formed by joining together a first chamber half in which one inlet is provided, the first chamber half

being draw-molded from a blank, and a second chamber half in which two outlets are provided, the second chamber half being draw-molded from a blank.

The branching member can be obtained by welding together the draw-molded first chamber half and the draw-molded second chamber half. Since draw molding and welding are easily performed, the manufacturing cost of the exhaust heat recovery device can be minimized.

Assembly can be accomplished merely by connecting the first flow channel and second flow channel to the branching member. The heat exchanger is preferably provided to the first flow channel in advance. An easily assembled exhaust heat recovery device is thus provided.

In a preferred form, the exhaust heat recovery device further comprises a merging member, provided between the outlet of the first flow channel and the valve chamber, for circulating the exhaust gas from the first flow channel to the valve chamber while the merging member comprises a single chamber formed by joining together a third chamber half in which two inlets are provided, the third chamber half being draw-molded from a blank, and a fourth chamber half in which one outlet is provided, the fourth chamber half being draw-molded from a blank.

The merging member can be obtained by welding together the draw-molded third chamber half and the draw-molded fourth chamber half. Since draw molding and welding are easily performed, the manufacturing cost of the exhaust heat recovery device can be minimized.

Preferably, the heat exchanger has an inlet directly connected to the branching member, and the heat exchanger has an outlet directly connected to the merging member.

Since the heat exchanger can be directly connected to the branching member and the merging member, there is no need to provide a member between the branching member and the

heat exchanger, and there is no need to provide a member between the heat exchanger and the merging member.

It is desirable that the outlet of the second flow channel have an outside diameter larger than the outlet of the merging member. It is also desirable that the valve chamber have an inside
5 diameter larger than a diameter of the outlet of the merging member while the second flow channel have a distal end passing through the outlet of the merging member and into the valve chamber.

Exhaust gas that flows through the second flow channel can be discharged to the valve chamber. The inside diameter of the valve chamber can be larger than the diameter of the outlet
10 of the merging member. Specifically, the diameter of the outlet of the merging member can be smaller than the inside diameter of the valve chamber. The outlet of the merging member can be constricted with respect to the valve chamber. Since the outlet of the merging member is constricted, the exhaust gas in the valve chamber does not readily flow back to the merging member. A smooth flow of exhaust gas is thus achieved.

15 It is preferable that the inlet of the branching member be positioned so that a central axis of the inlet substantially coincides with a central axis of the other outlet, a curved pipe for introducing the exhaust gas be provided to the inlet, and the other outlet form a reducer part with an inside diameter decreasing along the flow of the exhaust gas, an inlet diameter of the reducer part being larger than an inside diameter of the curved pipe.

20 The curved pipe causes the flow of exhaust gas to be angled with respect to the central axis of the inlet of the branching member. In this state, the exhaust gas flows

into the branching member. Since the reducer part has a large inlet diameter, exhaust gas is lead to the reducer part despite flowing at an angle. Specifically, a smooth flow of exhaust gas is maintained despite the connection of the curved pipe to the inlet.

5 Preferably, the central axis of the one outlet is offset toward the heat exchanger from the central axis of the inlet.

Even when the exhaust gas flows at an angle into the branching member toward the heat exchanger, since the other outlet is positioned toward the heat exchanger, the exhaust gas smoothly reaches the other outlet. A smooth flow of exhaust gas is
10 maintained.

Desirably, inclination angles of the inside surfaces of the reducer part with respect to the central axis of the other outlet are configured so that the inclination angle of the inside surface that is closer to the heat exchanger is greater than the inclination angle of the inside surface that is farther from the heat exchanger.

15 Of the inclination angles of the inside surfaces of the regulator, the inclination angle of the inside surface that is closer to the heat exchanger is larger. Even when the exhaust gas flows at an angle into the branching member toward the heat exchanger, when the inside surface has a large inclination angle, there is no risk of the flow of exhaust gas becoming disordered. A smooth flow of exhaust gas is thereby
20 maintained.

BRIEF DESCRIPTION OF THE DRAWINGS

Certain preferred embodiments of the present invention will be described in detail below, by way of example only, with reference to the accompanying drawings, in which:

FIGS. 1A through 1F are schematic views illustrating the process for manufacturing a branching member according to the present invention;

FIG. 2 is an exploded view showing an exhaust heat recovery device according to the present invention;

5 FIG. 3 is a sectional view showing the exhaust heat recovery device;

FIG. 4 is a perspective view showing the exhaust heat recovery device;

FIG. 5 is an enlarged view of portion 5 of FIG. 3;

FIG. 6 is a sectional view taken along line 6-6 of FIG. 3;

FIG. 7 is a view showing an operation of a second flow channel;

10 FIG. 8 is a view showing the operation of a first flow channel;

FIG. 9 is a view showing the operation of the heat exchanger;

FIG. 10 is an enlarged view of portion 10 of FIG. 9;

FIG. 11 is a view showing a modification of the exhaust heat recovery device of FIG. 3;

15 FIG. 12 is a view showing a modification of the exhaust heat recovery device of FIG. 11; and

FIG. 13 is a sectional view showing a conventional exhaust heat recovery device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIG. 1A, a blank 11 and a blank 12 are provided.

20 A draw-molded article 13 and a draw-molded article 14 are then obtained by a draw-molding process, as shown in FIG. 1B.

The draw-molded article 13 and the draw-molded article 14 are then trimmed by cutting along cutting lines 15, 16, 17, 18, as shown in FIG. 1C.

By the process described above, the first chamber half 21 and second chamber half 22 shown in FIG. 1D are obtained. The first chamber half 21 is composed of a

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first bottom 23 and a first wall 24 that stands upright on the periphery of the first bottom 23. An inlet 25 is provided in the first bottom 23. The second chamber half 22 is composed of a second bottom 26 and a second wall 27 that stands upright on the periphery of the second bottom 26. One outlet 28 and another outlet 29 are provided to the second bottom 26. Exhaust gas for heat recovery is discharged from the one outlet 28.

As shown in FIG. 1E, the second chamber half 22 is fitted in the first chamber half 21. A mating part 31 is then bonded using a welding torch 32.

As shown in FIG. 1F, a chamber-shaped branching member 33 is obtained.

The constituent elements of the exhaust heat recovery device 40 of the present invention will be described based on FIG. 2.

As shown in FIG. 2, the exhaust heat recovery device 40 is composed of the branching member 33; a first flow channel 41 connected to the one outlet 28 of the branching member 33; a heat exchanger 42 provided to the first flow channel 41; a second flow channel 43 connected to the other outlet 29 of the branching member 33; a valve 44 for blocking an outlet of the second flow channel 43; a merging member 45 connected to the first flow channel 41 and second flow channel 43; and a valve chamber 46 for surrounding the valve 44 connected to the merging member 45. An outlet of an exhaust pipe extending from an internal combustion engine is connected to the inlet 25 of the branching member 33. However, in this example, an introduction member 47 is connected to the inlet 25, and the outlet of the exhaust pipe is connected to the introduction member 47.

The heat exchanger 42 is composed of a core case 48; an entrance-side end plate 49 for blocking an inlet of the core case 48; an exit-side end plate 51 for blocking an outlet of the core case 48; a plurality of heat transfer tubes 52 housed in the core case

48 so as to penetrate through the entrance-side end plate 49 and the exit-side end plate 51; an entrance-side extension 53 which extends toward the branching member 33 from the entrance-side end plate 49; and an exit-side extension 54 which extends toward the merging member 45 from the exit-side end plate 51. The entrance-side extension 53 and the exit-side extension 54 each serve as a first flow channel 41. High-temperature exhaust gas flows into the heat transfer tubes 52. Low-temperature coolant is circulated outside the heat transfer tubes 52. The heat of the exhaust gas moves to the coolant via the heat transfer tubes 52. The temperature of the exhaust gas decreases, and the temperature of the coolant increases. Waste heat is thus recovered.

The second flow channel 43 comprises a straight metal tube. The sealing ability of the valve 44 is increased by providing a retainer member 50 to the outlet of the second flow channel 43.

The merging member 45 is manufactured by the same process as the branching member 33. Since FIGS. 1A through 1F can be referred to for this process, no further description thereof will be given.

The merging member 45 is a chamber provided with two inlets 55, 56 and one outlet 57. Specifically, the merging member 45 is composed of a third chamber half 58 which is provided with two inlets 55, 56, and a fourth chamber half 59 which is provided with one outlet 57.

The valve chamber 46 is a metal tube having a larger inside diameter than the outlet 57.

The method of assembly will next be described.

The introduction member 47 is inserted in the inlet 25 of the branching member 33.

The entrance-side extension 53 corresponding to the inlet of the first flow channel 41 is inserted in the one outlet 28 of the branching member 33. The exit-side extension 54 corresponding to the outlet of the first flow channel 41 is inserted in one inlet 55 of the merging member 45.

5 A means must be devised to attach the second flow channel 43. Specifically, the second flow channel 43 is inserted in the merging member 45 so as to pass through the outlet 57 and other inlet 56 of the merging member 45. The inlet of the second flow channel 43 is also inserted in the other outlet 29 of the branching member 33.

The inlet of the valve chamber 46 is placed against (touching) the outlet of the
10 merging member 45.

As shown in FIG. 3, the introduction member 47 is joined to the branching member 33 by a first bead 61, the entrance-side extension 53 is joined to the branching member 33 by a second bead 62, and the exit-side extension 54 is joined to the merging member 45 by a third bead 63. The inlet of the second flow channel 43 is joined to the
15 branching member 33 by a fourth bead 64, and the outlet of the second flow channel 43 is joined to the merging member 45 by a fifth bead 65. The valve chamber 46 is joined to the merging member 45 by a sixth bead 66.

Pre-welding assembly is completed by placing against or inserting the first flow channel 41, second flow channel 43, and valve chamber 46 into the chamber-shaped
20 branching member 33 and chamber-shaped merging member 45. After this assembly, the welding is performed merely by joining together the first through sixth beads 61 through 66, and is therefore easily performed. Assembly is thereby facilitated.

The overall form of the exhaust heat recovery device 40 will next be described based on FIG. 4.

As shown in FIG. 4, a valve shaft 67 passes over the valve chamber 46. A disc 69 is attached to one end of the valve shaft 67 via a torsion spring 68. A lever 71 extends from the disc 69, and a rod 73 of a thermo-actuator 72 is connected to the lever 71. The thermo-actuator 72 is mounted on the heat exchanger 42.

5 The coolant is introduced from a medium inlet 74 of the thermo-actuator 72. The coolant exits from a medium outlet 75 after heating or cooling a thermal wax housed in the thermo-actuator 72. In the event that the coolant reaches a high temperature, the thermal wax expands, and the rod 73 advances as indicated by the arrow (2). Such advancing causes the lever 71 to rotate as indicated by the arrow (3),
10 and the valve shaft 67 also rotates via the torsion spring 68 in the direction indicated by the arrow (3).

The relevant parts of FIG. 3 will be described based on FIGS. 5 through 7.

As shown in FIG. 5, the outside diameter of the outlet of the second flow channel 43 is larger than the diameter of the outlet 57 of the merging member 45. Exhaust
15 gas flows from the merging member 45 to the valve chamber 46 through a gap t that corresponds to half the difference in diameter. The inside diameter of the valve chamber 46 is larger than the diameter of the outlet 57 of the merging member 45, and a distal end of the second flow channel 43 passes through the outlet 57 of the merging member 45 and into the valve chamber 46. During exhaust heat non-recovery, the
20 exhaust gas flows into the valve chamber 46 from the second flow channel 43. The exhaust gas at this time preferably does not flow back into the merging member 45 from the valve chamber 46. As shown in FIG. 5, the outlet 57 of the merging member 45 is constricted with respect to the valve chamber 46. Since the outlet is constricted, there is no risk of backflow of the exhaust gas of the valve chamber 46 into the
25 merging member 45. An end part 76 of the second flow channel 43 is also subjected to

a tube expansion process so that the outside diameter of the end part 76 is larger than the diameter of the outlet 57. Since the end part 76 is curved so as to approach the inside surface of the valve chamber 46, backflow of the exhaust gas is further prevented.

5 As shown in FIG. 6, the valve shaft 67 is supported by the valve chamber 46 so as to be able to rotate. Exhaust gas is prevented from leaking to the outside by seal rings 77, 77. The valve 44 is fixed to the valve shaft 67 by bolts 78, 78.

 The outlet 57 is provided so as to cover one-half the circumference of the second flow channel 43. The end part 76 of the second flow channel 43 is fitted in the outlet
10 57. Giving the outlet 57 a length of one-half circumference ensures a degree of freedom in assembling the fourth chamber half 59 in the second flow channel 43. When the length exceeds one-half circumference, the second flow channel 43 is moved only in the front-back direction of the drawing, and the degree of freedom is reduced. A length of less than one-half circumference may cause the exhaust gas in the valve
15 chamber 46 to flow back.

 An operation of the exhaust heat recovery device 40 configured as described above will next be described.

 During acceleration or travel, when the flow rate of exhaust gas discharged from the internal combustion engine is high, the valve 44 is opened by the pressure of the
20 exhaust gas, as shown in FIG. 7. The flow channel resistance of the second flow channel 43 is low. The second flow channel 43 is capable of accommodating a large flow of exhaust gas. Since the valve shaft 67 is rotated against the torsion spring by the pressure of the exhaust gas, a valve-open state occurs regardless of the position of the rod 73 of the thermo-actuator 72.

When the temperature of the coolant for cooling the internal combustion engine is high, the rod 73 in FIG. 7 advances, the valve shaft 67 is rotated via the torsion spring, and a valve-open state occurs. In the valve-open state, exhaust gas flows into the second flow channel 43, and no heat recovery takes place. Since one purpose of heat recovery is to warm the coolant, heat recovery is not performed when the coolant is already at a high temperature.

When the flow rate of exhaust gas is low and the temperature of the coolant is low, the rod 73 retreats, and the second flow channel 43 is closed by the valve 44 as shown in FIG. 8.

The exhaust gas flows through the first flow channel 41, as shown in FIG. 9. Heat is exchanged by the heat exchanger 42, and the heat of the exhaust gas is transferred to the coolant.

As shown in FIG. 10, the outlet 29 is formed in a curved shape by draw-molding. When the second flow channel 43 is placed against a flat plate and fillet welded, a bead is formed at the location of maximum stress. There is a risk of cracks forming in the fillet weld due to repeated temperature variations.

Forming in a curved shape as shown in FIG. 10 makes it possible to position the fourth bead 64 away from the location of maximum stress. The stress at the fourth bead 64 can be reduced. The same reduction in stress occurs at the first through third beads and at the fifth bead.

A modification of the configuration shown in FIG. 3 will be described based on FIG. 11. In FIG. 11, elements that are the same as those in FIG. 3 are referred to by the same symbols as in FIG. 3, and no description thereof will be given.

As shown in FIG. 11, in the branching member 33, the central axis 25a of the inlet 25 of the branching member 33 substantially coincides with the central axis 29a

of the other outlet 29. A curved pipe 79 for introducing exhaust gas is connected to the inlet 25. The other outlet 29 forms a reducer part 80, the inside diameter of which decreases along the flow of exhaust gas, and the inlet diameter of the reducer part 80 is larger than the inside diameter of the curved pipe 79.

5 The curved pipe 79 causes the exhaust gas to flow along an inclined line 81. The inclined line 81 is inclined with respect to the central axis 25a of the inlet 25. In this state, the exhaust gas flows into the branching member 33. Since the reducer part 80 has a large inlet diameter, exhaust gas is lead to the reducer part 80 despite flowing at an angle. Specifically, a smooth flow of exhaust gas is maintained despite
10 the connection of the curved pipe 79 to the inlet 25.

 The outlet of the reducer part 80 has a small or reduced diameter, and the second flow channel 43 is connected to this outlet. The second flow channel 43 also has a small or reduced diameter and is recessed by an amount δ from a line 82 connecting the inlet of the reducer part 80 and the valve chamber 46. On-board
15 equipment and the like can be placed in the depression thus formed.

 It should also be noted that the first chamber half 21 is tapered by causing it to be partially curved or depressed toward the heat exchanger 42 by a distance α . By provision of the tapered part, it becomes possible to increase the rigidity of the branching member 33 and to make the exhaust gas flow uniformly and smoothly
20 during heat recovery. The size of the heat recovery device can be reduced by the amount α .

 The central axis 29a of the other outlet 29 is preferably offset an amount β toward the heat exchanger 42 from the central axis 25a of the inlet 25.

Even when the exhaust gas flows in toward the heat exchanger 42 along the inclined line 81, since the other outlet 29 is positioned toward the heat exchanger 42, there is no risk of the exhaust gas leaving the other outlet 29.

5 In the reducer part 80, the inclination angles θ_1 , θ_2 of the inside surfaces of the regulator with respect to the central axis 29a of the other outlet 29 are preferably configured so that the inclination angle θ_2 of the inside surface that is closer to the heat exchanger 42 is greater than the inclination angle θ_1 of the inside surface that is farther from the heat exchanger 42.

10 The inside surface having the inclination angle θ_2 intersects with the inclined line 81, and the angle of intersection is near 90° . The exhaust gas that flows along the inclined line 81 thus flows against the inside surface having the inclination angle θ_2 . The exhaust gas is then guided by this inside surface toward the second flow channel 43. Specifically, even when the exhaust gas flows at an angle into the branching member 33 toward the heat exchanger 42, when the inside surface has a
15 large inclination angle, flow of the exhaust gas into the first flow channel 41 can be prevented and pressure loss can be reduced. A smooth flow of exhaust gas is thereby maintained.

A modification of the configuration shown in FIG. 11 will be described based on FIG. 12. In FIG. 12, elements that are the same as those in FIG. 11 are referred to by
20 the same symbols as in FIG. 11, and no description thereof will be given.

As shown in FIG. 12, the inclination angles of the inside surface of the reducer part 80 with respect to the central axis 29a of the other outlet 29 are θ_3 and θ_3 . An inlet center 79a of the curved pipe 79 is on the heat exchanger 42 side of the central axis 25a of the inlet 25 of the branching member 33. Setting the inclination angles to

63 enables the curved pipe 79 to be rotated about the central axis 25a of the inlet 25. Specifically, the curved pipe 79 can be oriented in any direction.

The exhaust heat recovery device 40 of the present invention can be provided to an exhaust pipe that extends from an internal combustion engine to a muffler, or may
5 be provided to an exhaust gas recirculation (EGR) duct for returning a portion of exhaust gas to an internal combustion engine. The exhaust heat recovery device 40 may also be used for other applications.

What Is Claimed Is:

1. An exhaust heat recovery device comprising:
 - a chamber-shaped branching member having one inlet for introducing exhaust
 - 5 gas and two outlets for discharging the exhaust gas;
 - a first flow channel, extending from one of the two outlets, for circulating the exhaust gas;
 - a heat exchanger, provided to the first flow channel, for recovering potential heat of the exhaust gas;
 - 10 a second flow channel, extending from other one of the two outlets, for circulating the exhaust gas while bypassing the heat exchanger; and
 - a valve chamber for housing a valve designed to open and closing the outlet of the second flow channel,
 - wherein the branching member comprises a single chamber formed by joining
 - 15 together a first chamber half in which one inlet is provided, the first chamber half being draw-molded from a blank, and a second chamber half in which two outlets are provided, the second chamber half being draw-molded from a blank.
2. The exhaust heat recovery device of claim 1, further comprising a merging
- 20 member, provided between the outlet of the first flow channel and the valve chamber, for circulating the exhaust gas from the first flow channel to the valve chamber, wherein the merging member comprises a single chamber formed by joining together a third chamber half in which two inlets are provided, the third chamber half being draw-molded from a blank, and a fourth chamber half in which one outlet is provided,
- 25 the fourth chamber half being draw-molded from a blank.

3. The exhaust heat recovery device of claim 1, wherein the heat exchanger has an inlet directly connected to the branching member, and the heat exchanger has an outlet directly connected to the merging member.
- 5 4. The exhaust heat recovery device of claim 1, wherein the outlet of the second flow channel has an outside diameter larger than the outlet of the merging member, the valve chamber has an inside diameter larger than a diameter of the outlet of the merging member, and the second flow channel has a distal end passing through the outlet of the merging member and into the valve chamber.
- 10 5. The exhaust recovery device of claim 1, wherein the inlet of the branching member is positioned so that a central axis of the inlet substantially coincides with a central axis of the other outlet, a curved pipe for introducing the exhaust gas is provided to the inlet, and the other outlet forms a reducer part with an inside diameter decreasing
- 15 along the flow of the exhaust gas, an inlet diameter of the reducer part being larger than an inside diameter of the curved pipe.
6. The exhaust heat recovery device of claim 5, wherein the one outlet has a central axis being offset toward the heat exchanger from a central axis of the inlet.
- 20 7. The exhaust heat recovery device of claim 5, wherein inclination angles of the inside surfaces of the reducer part with respect to the central axis of the other outlet are configured so that the inclination angle of the inside surface that is closer to the heat exchanger is greater than the inclination angle of the inside surface that is
- 25 farther from the heat exchanger.

FIG.1A

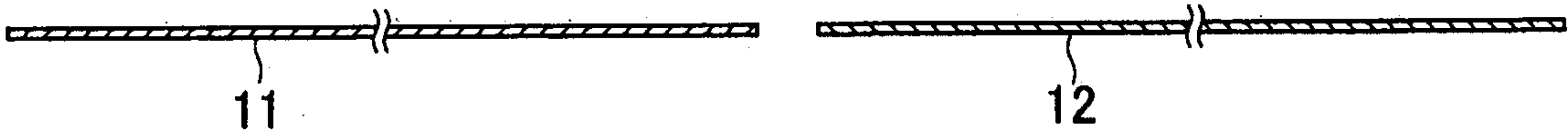


FIG.1B

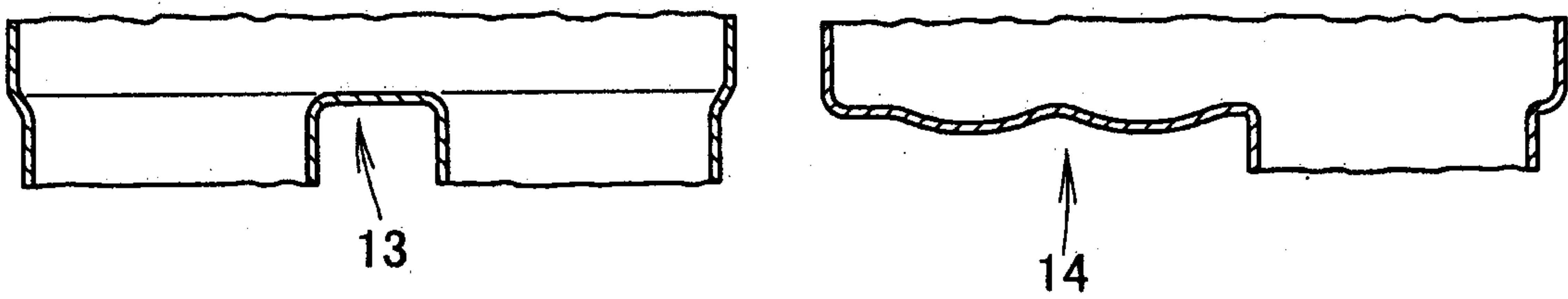
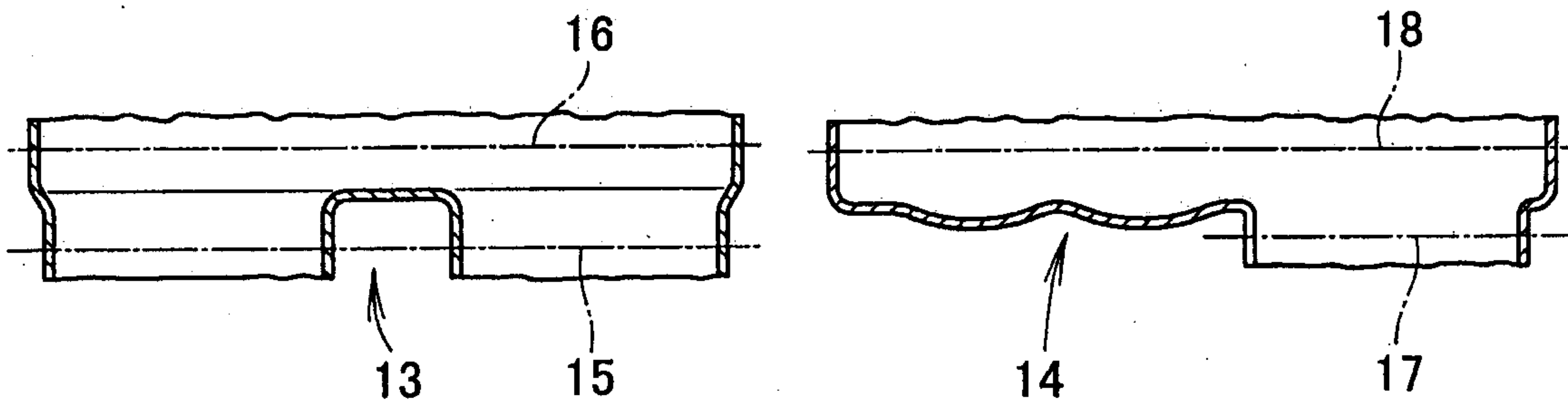


FIG.1C



*Patent Agents
Smart & Biggar*

FIG.1D

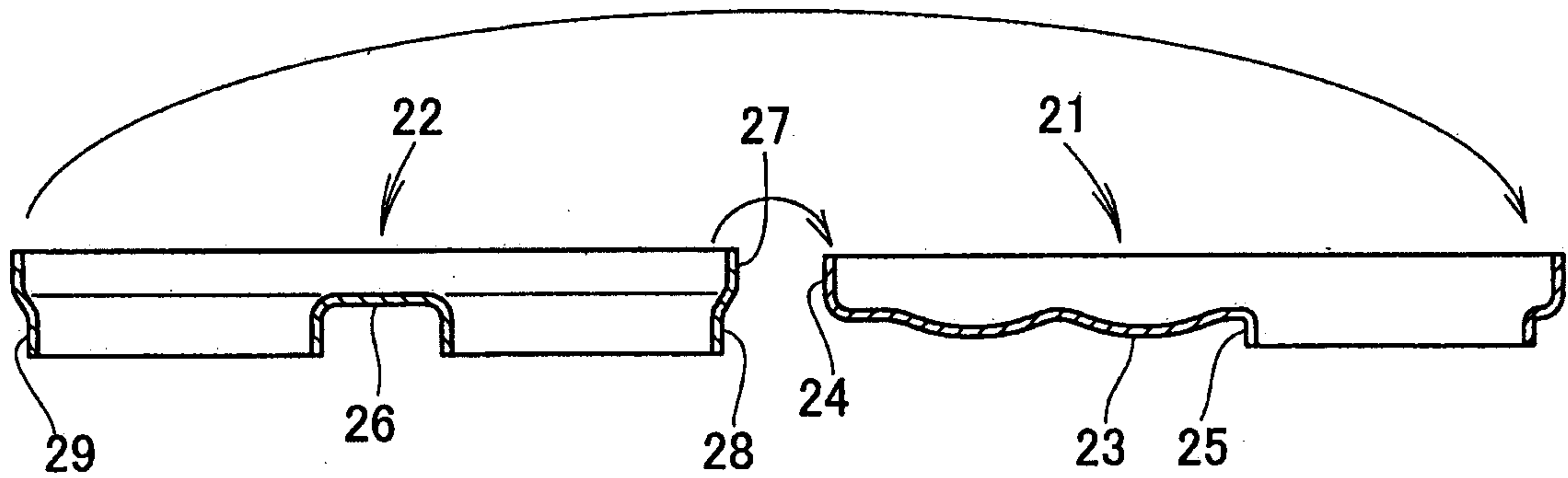


FIG.1E

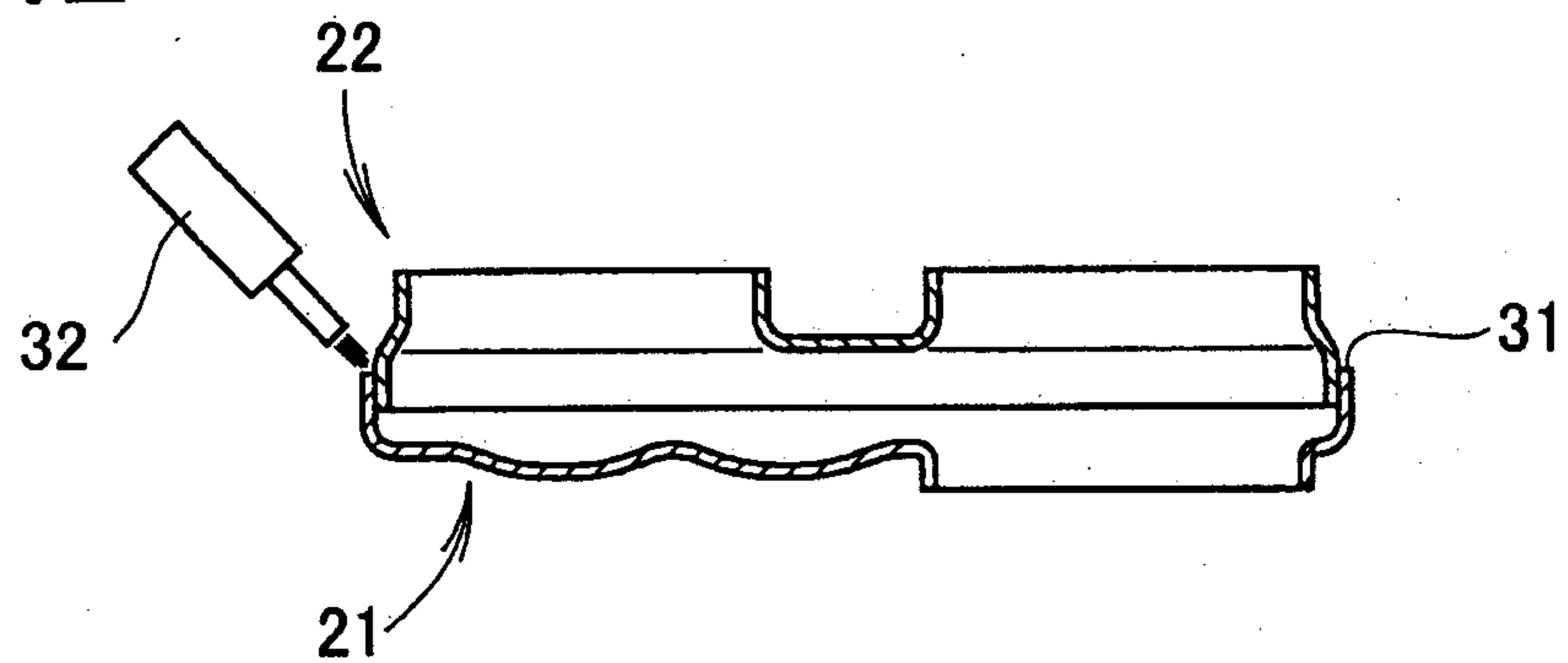
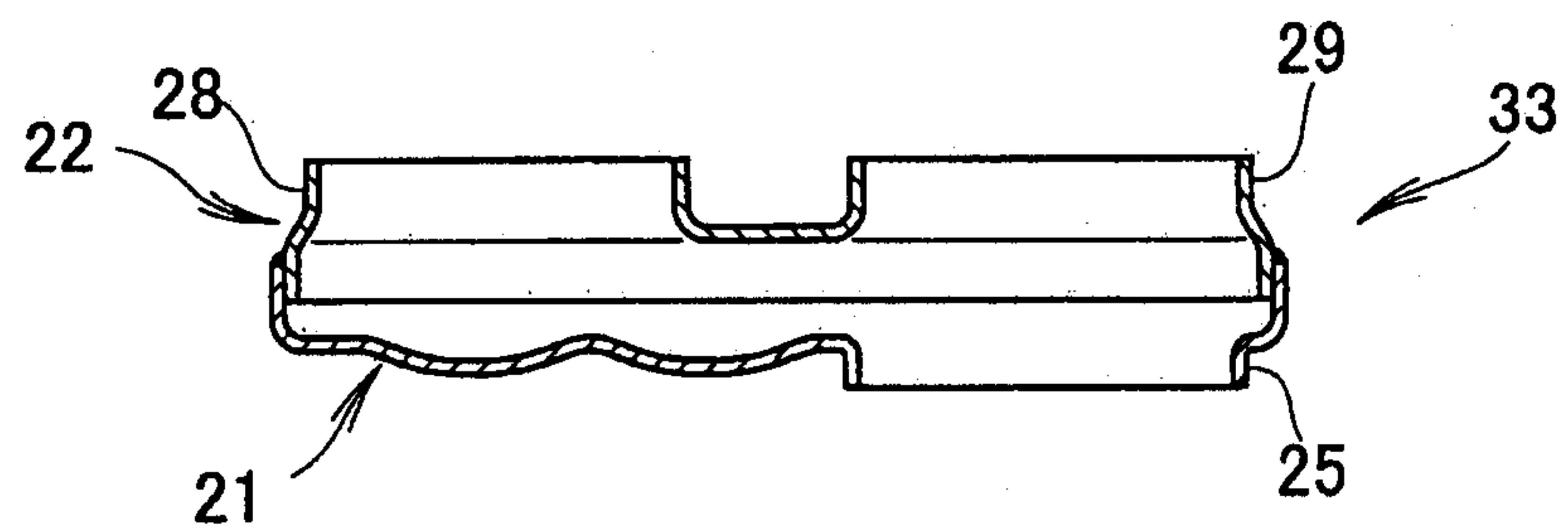
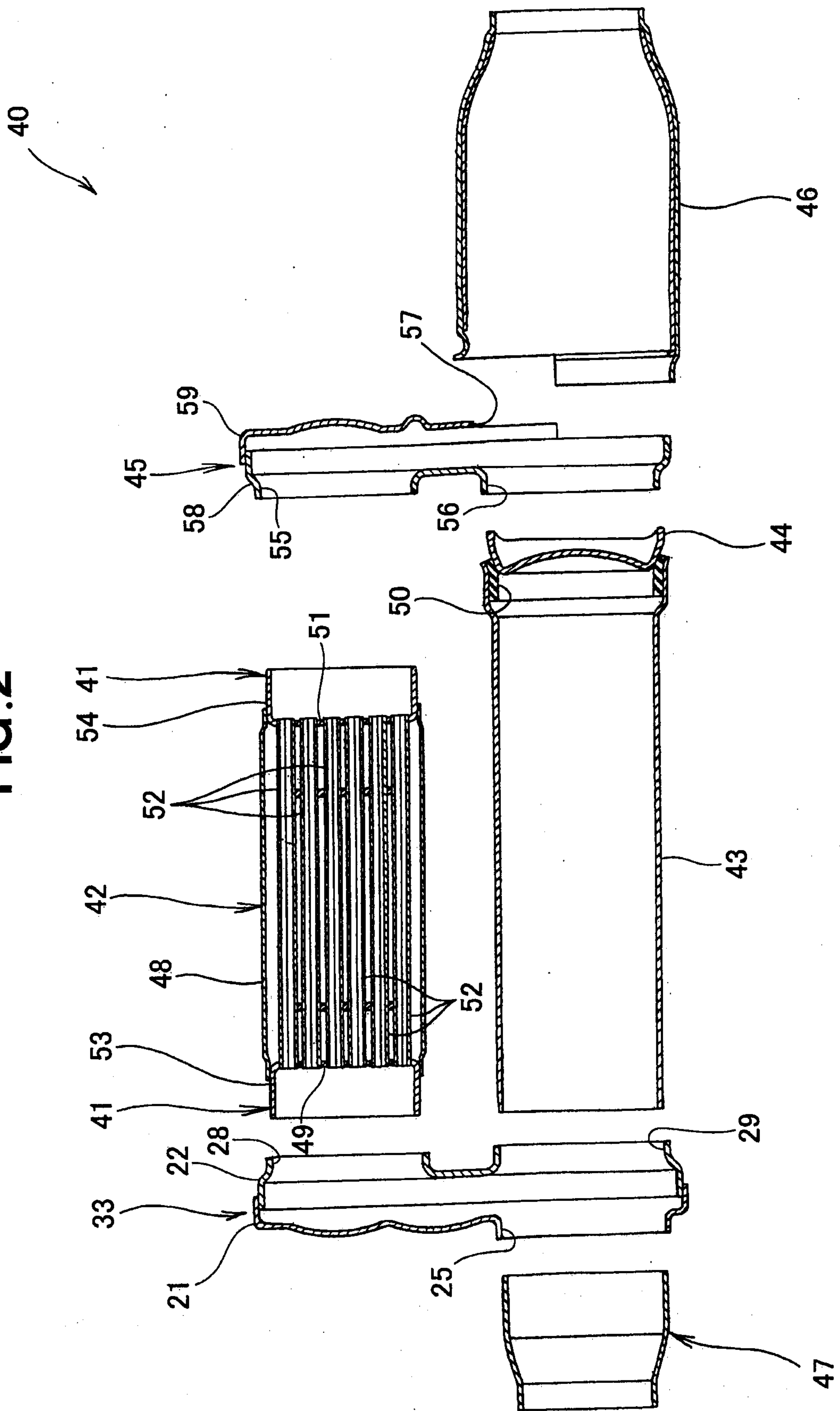


FIG.1F

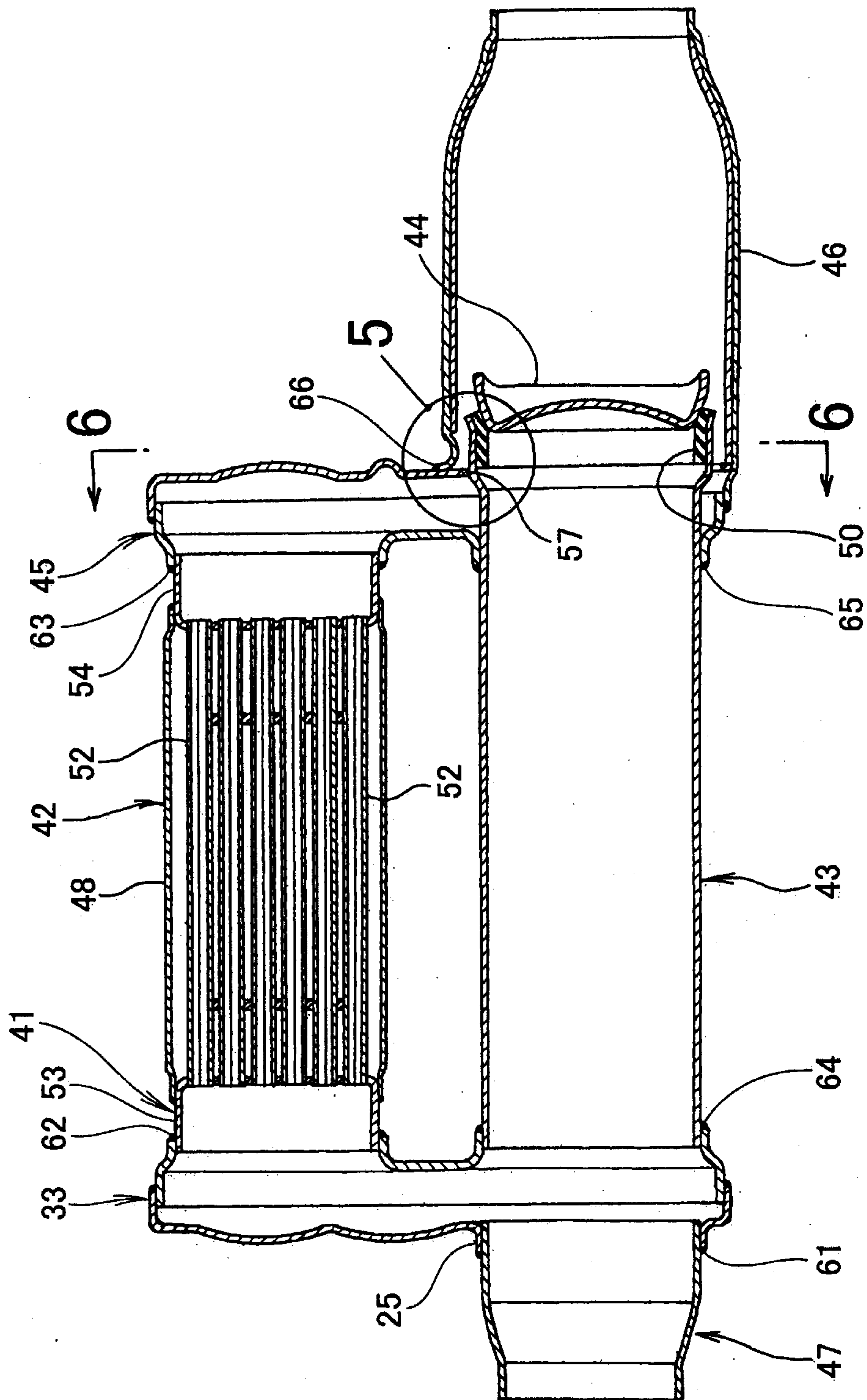


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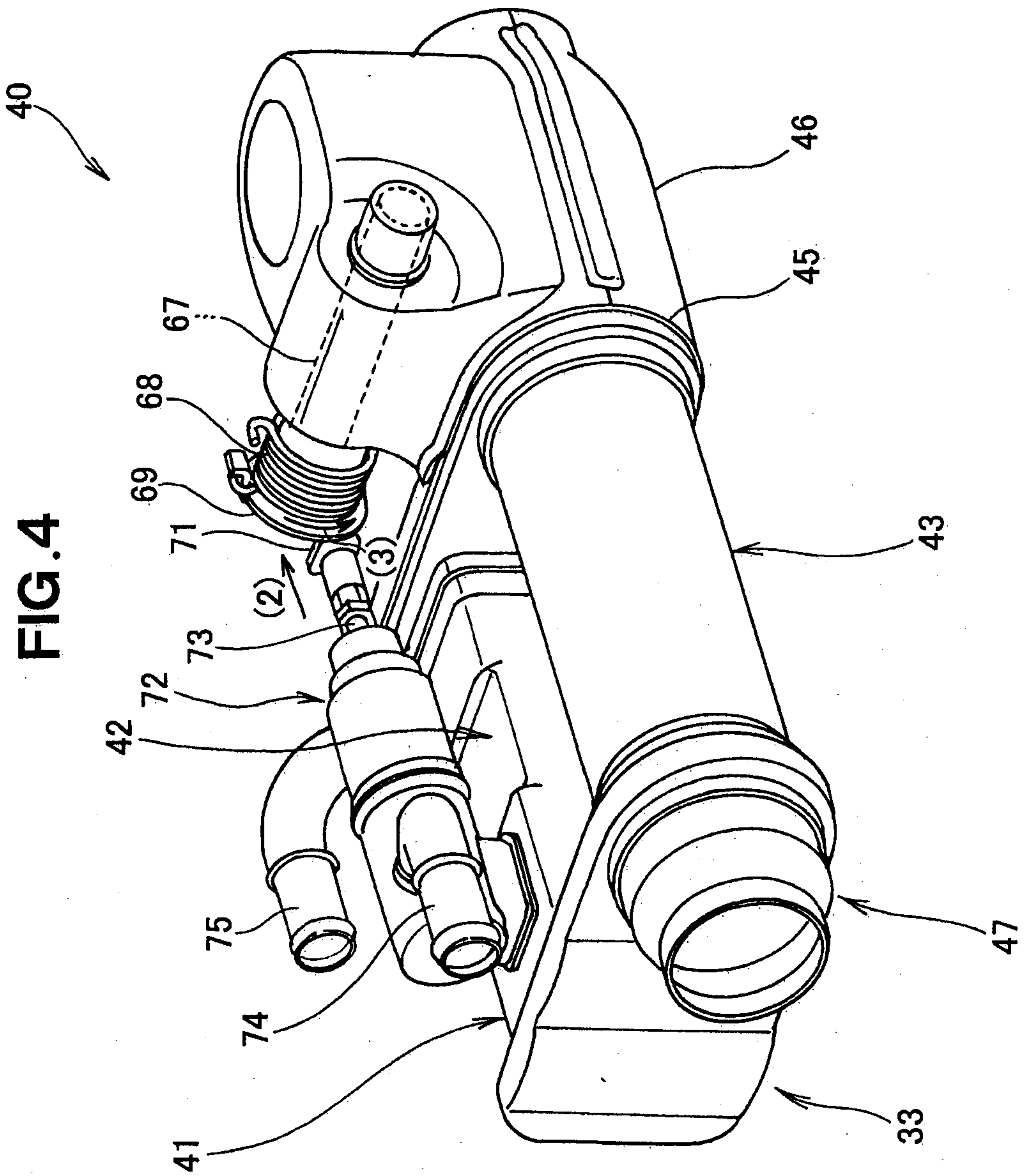
FIG. 2

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FIG. 3



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FIG.5

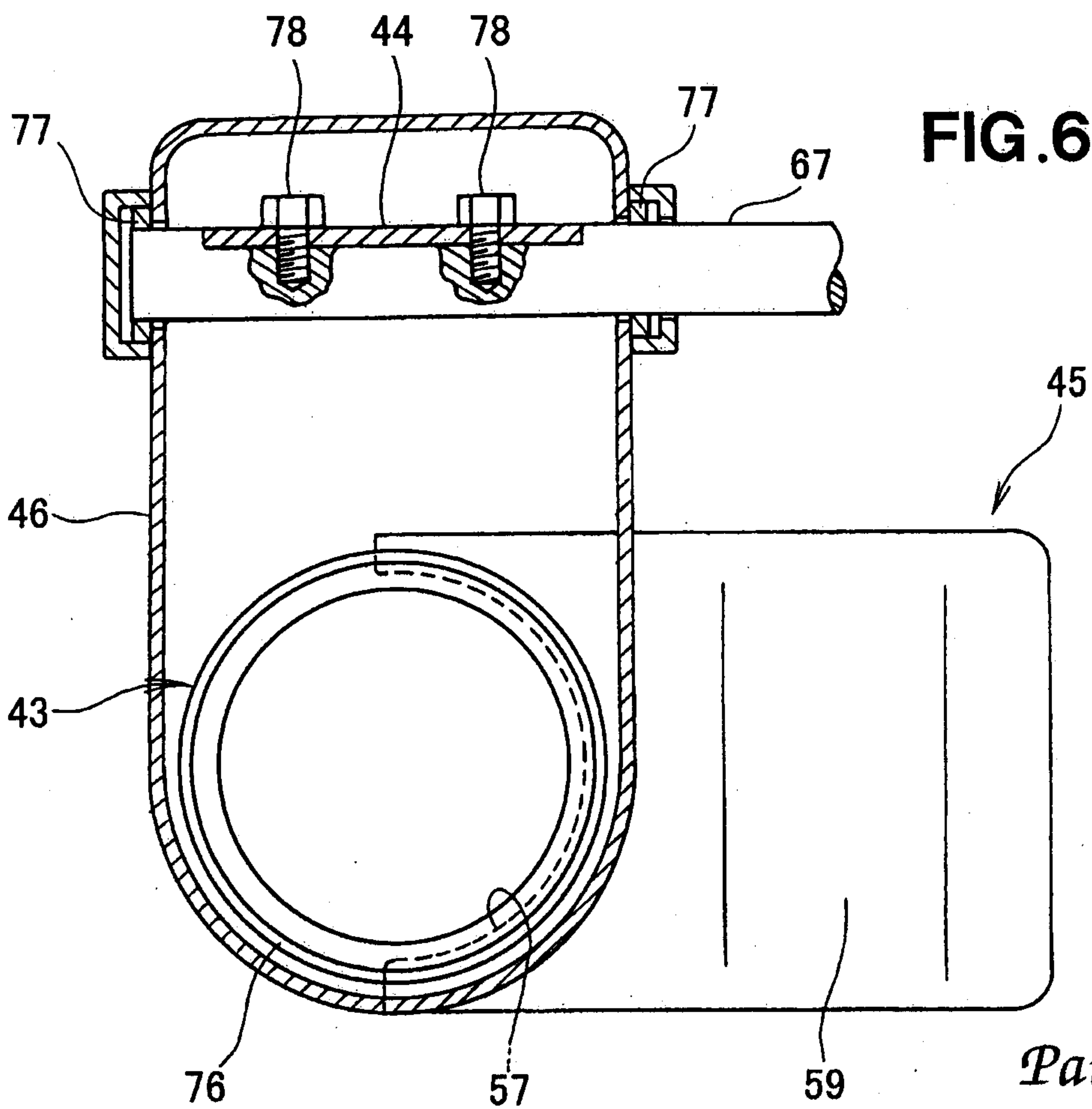
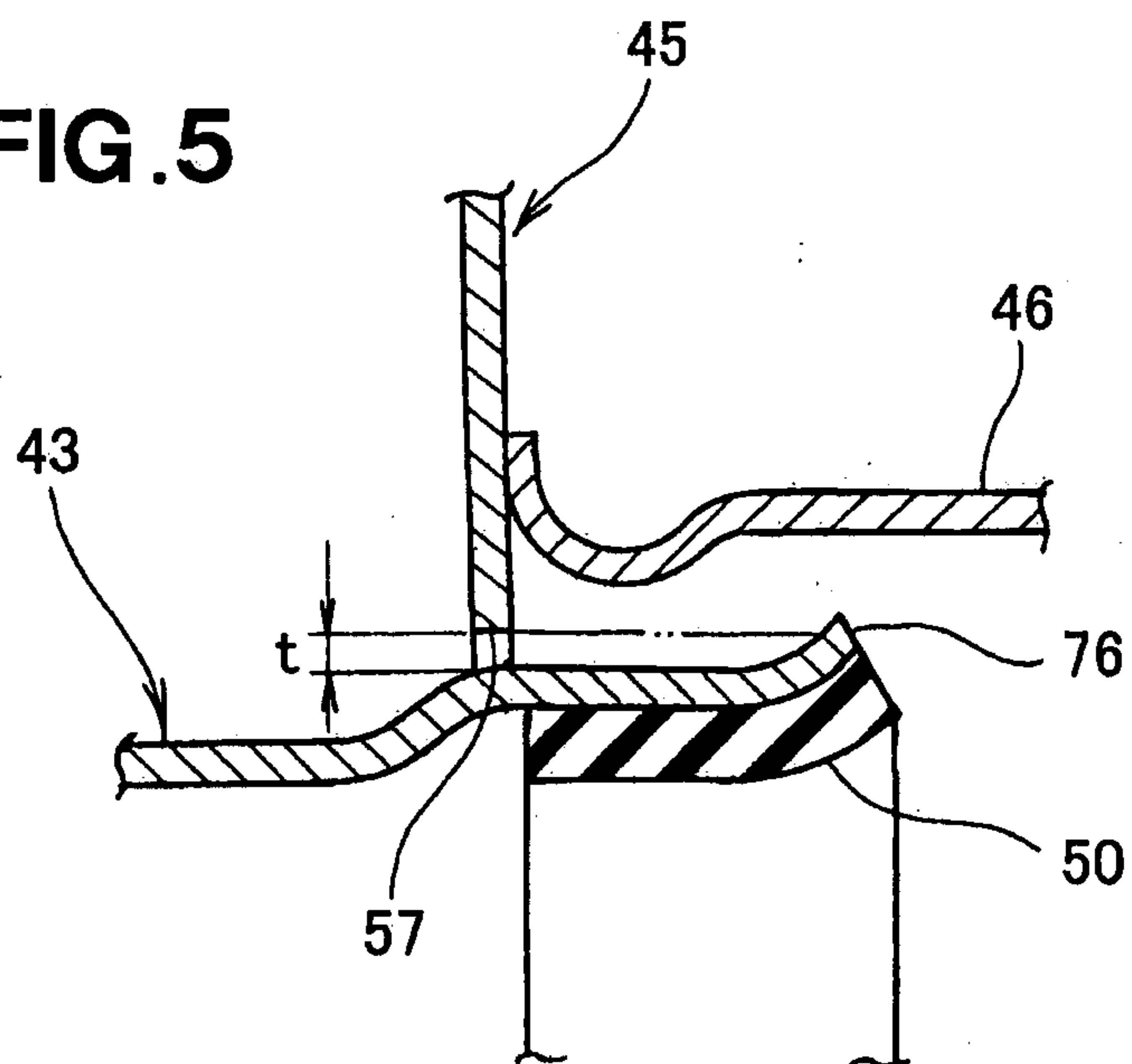


FIG.6

FIG.7

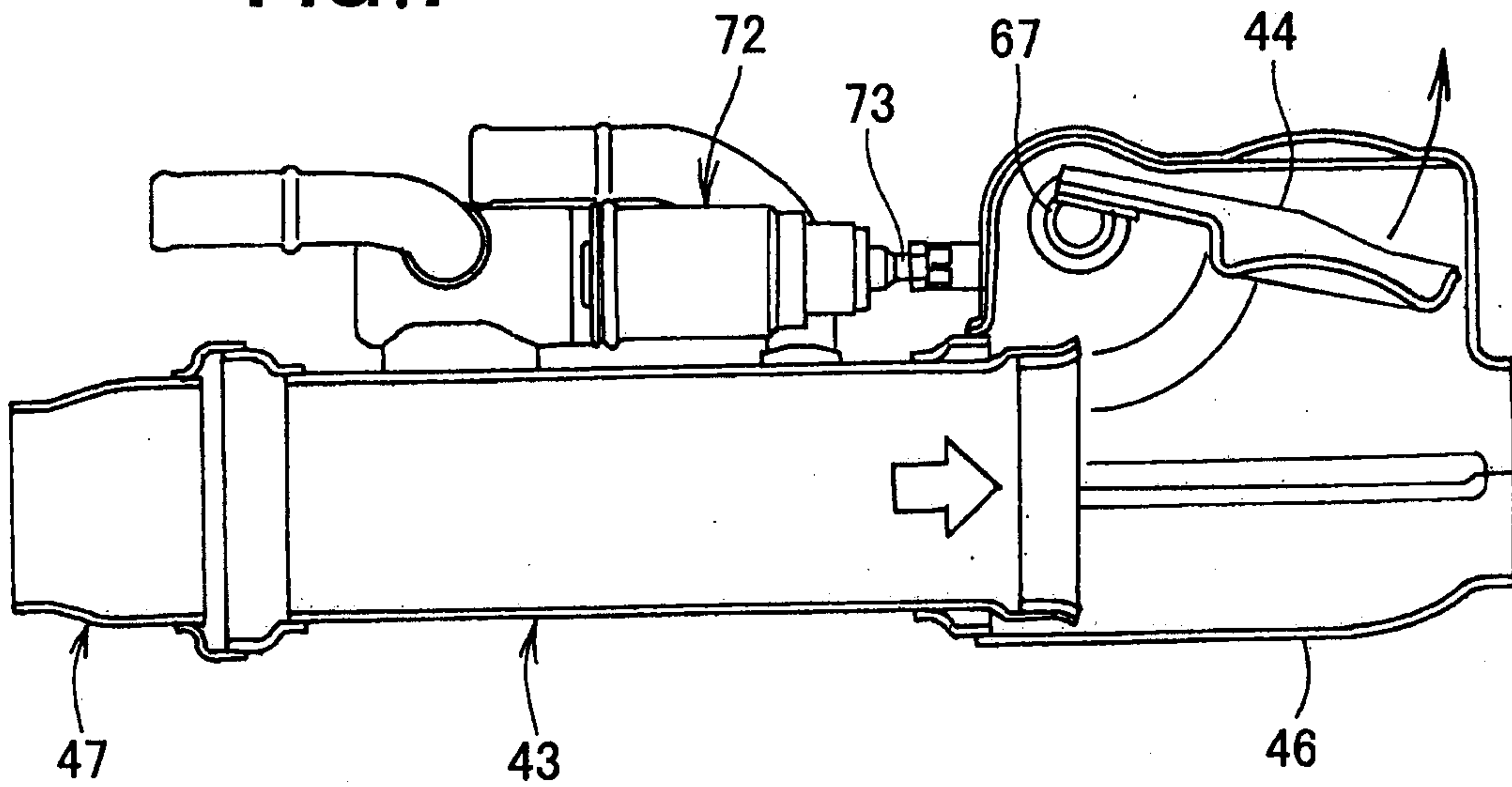
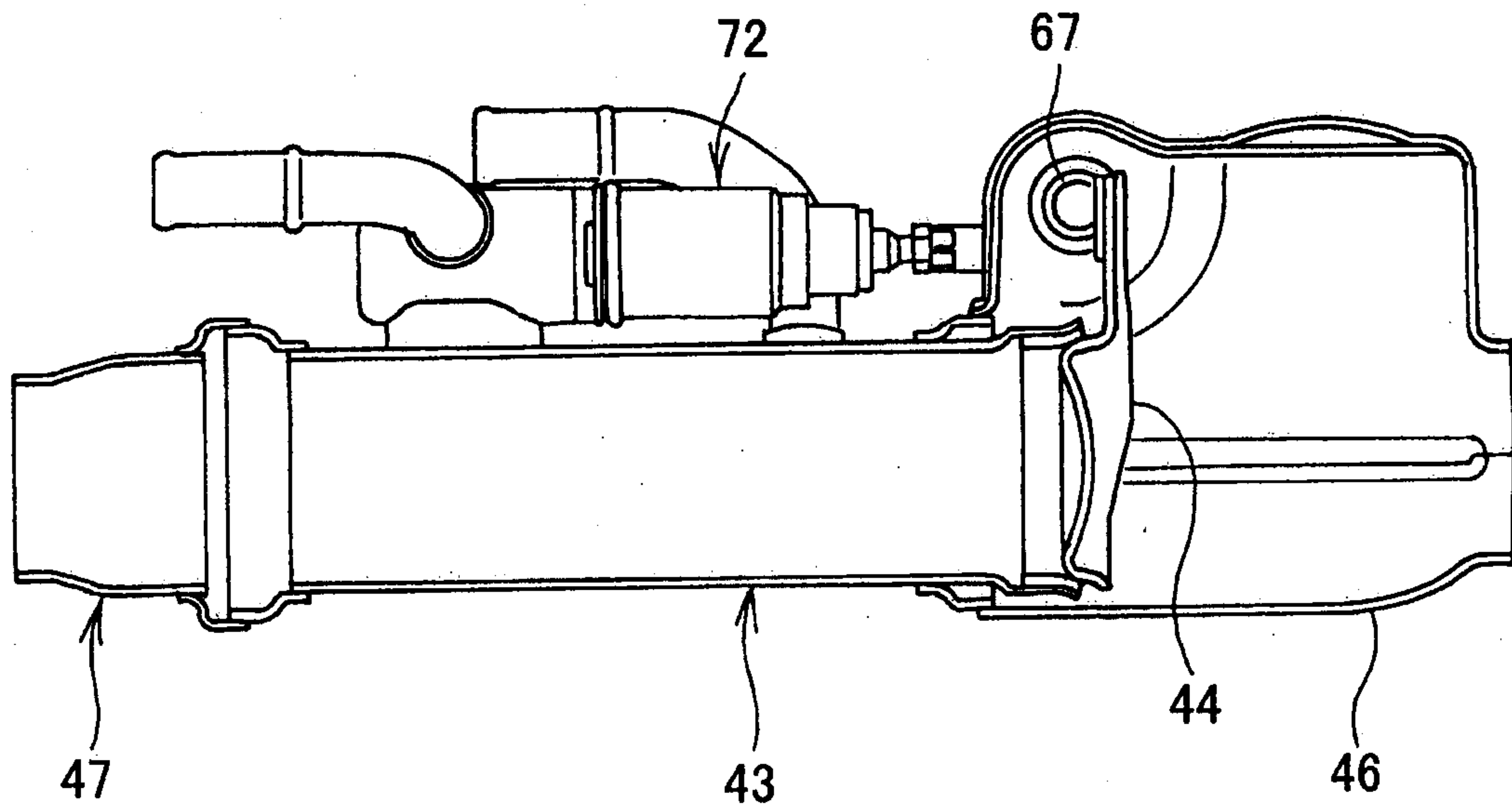


FIG.8



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FIG.9

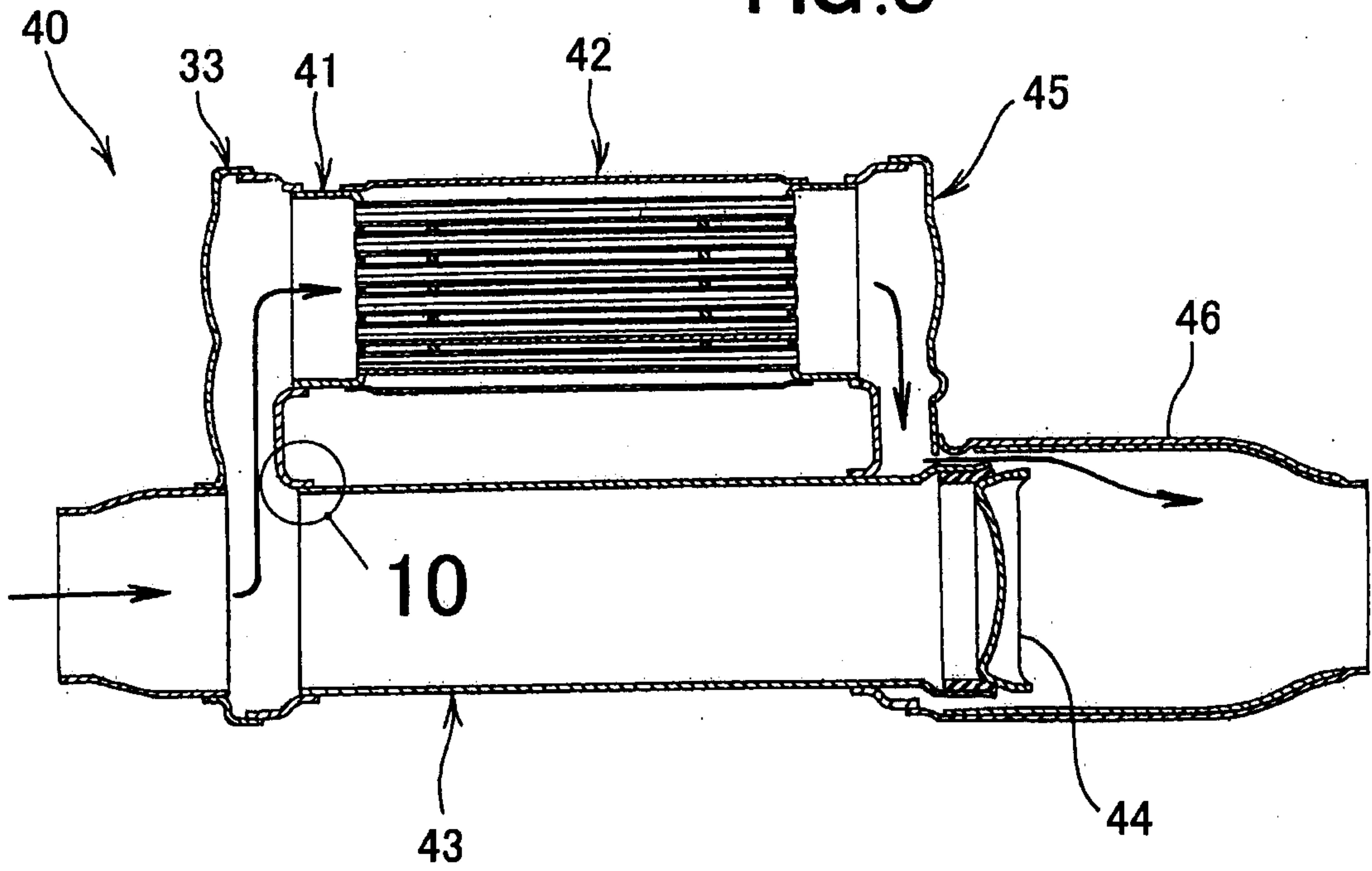
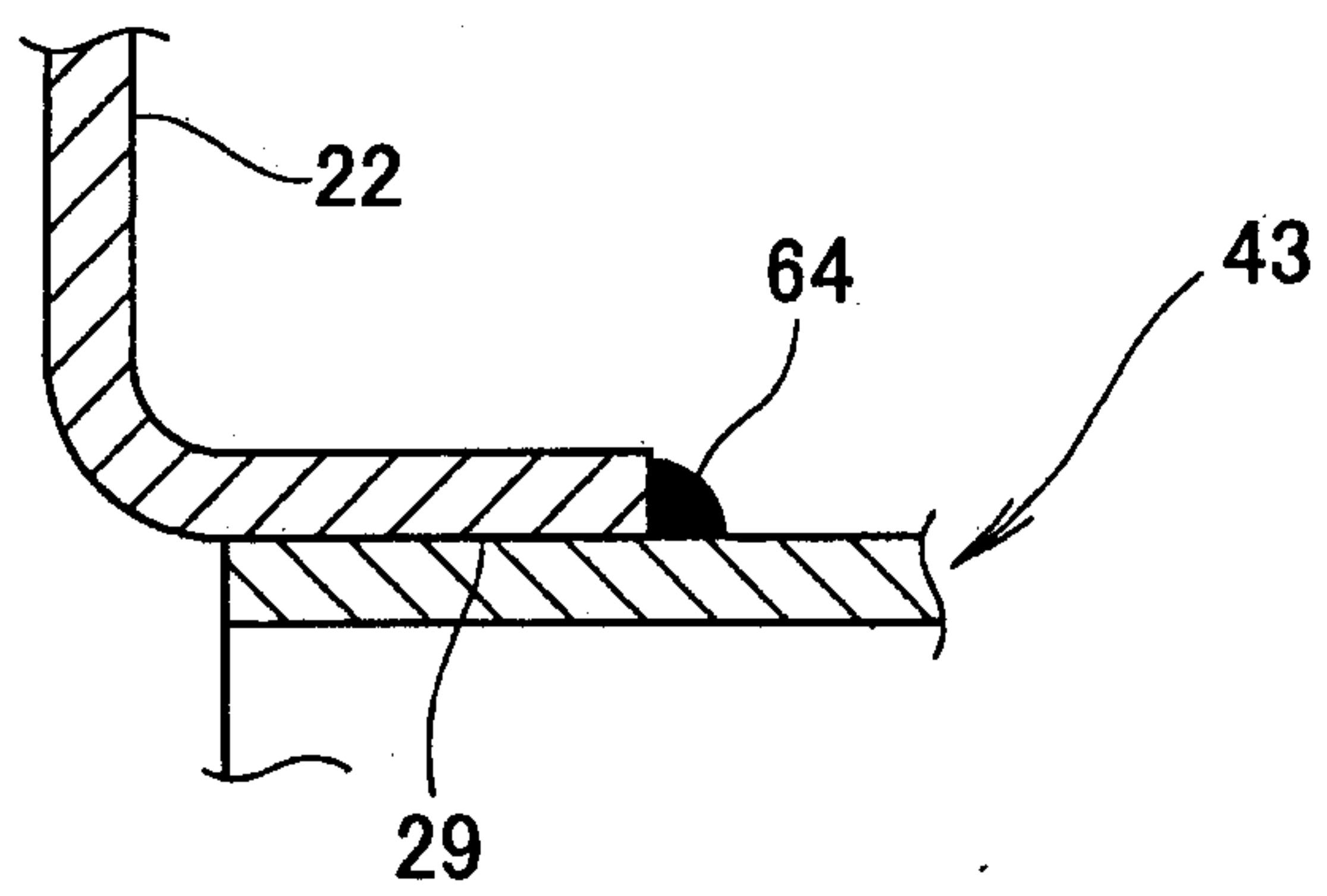
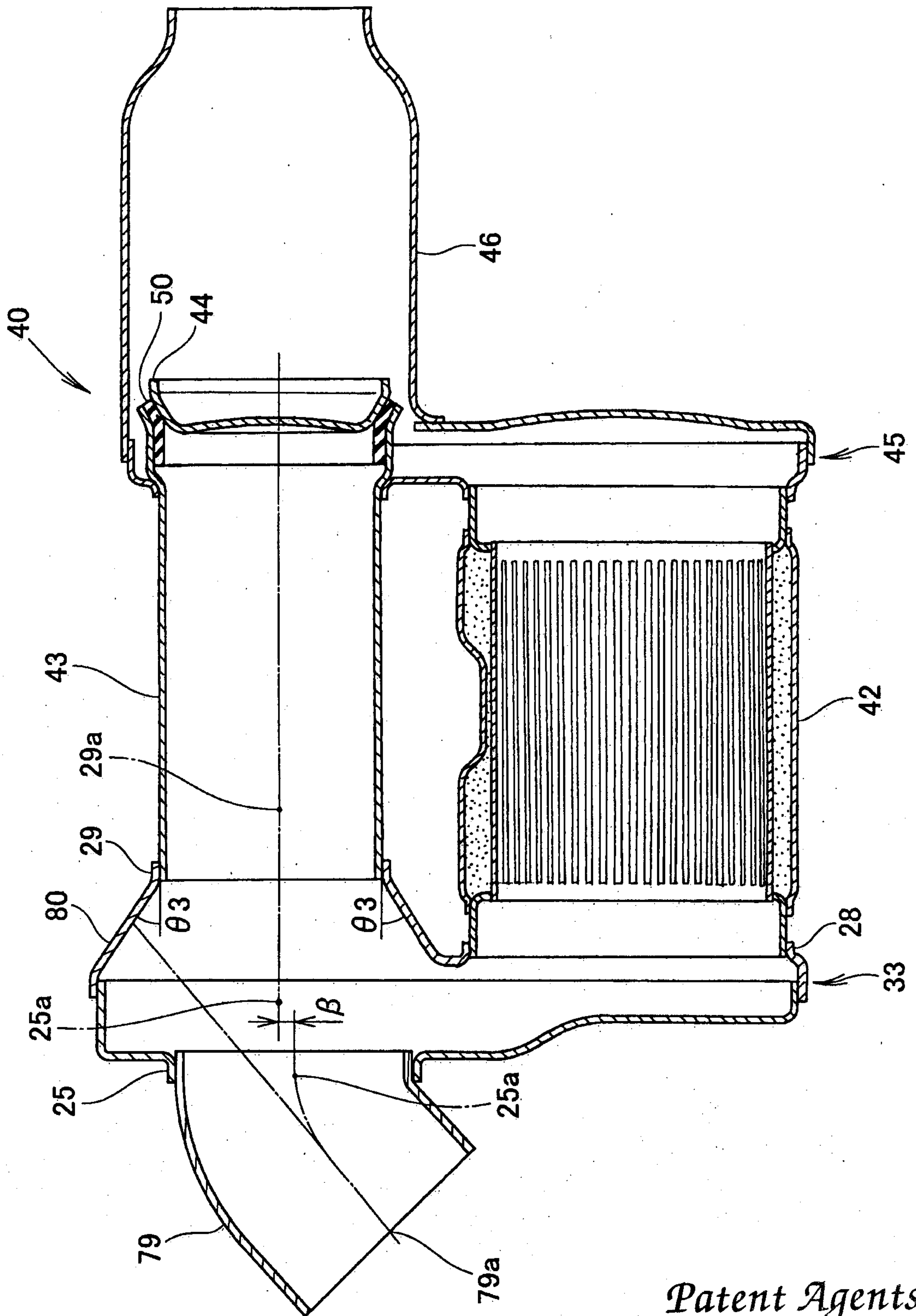


FIG.10



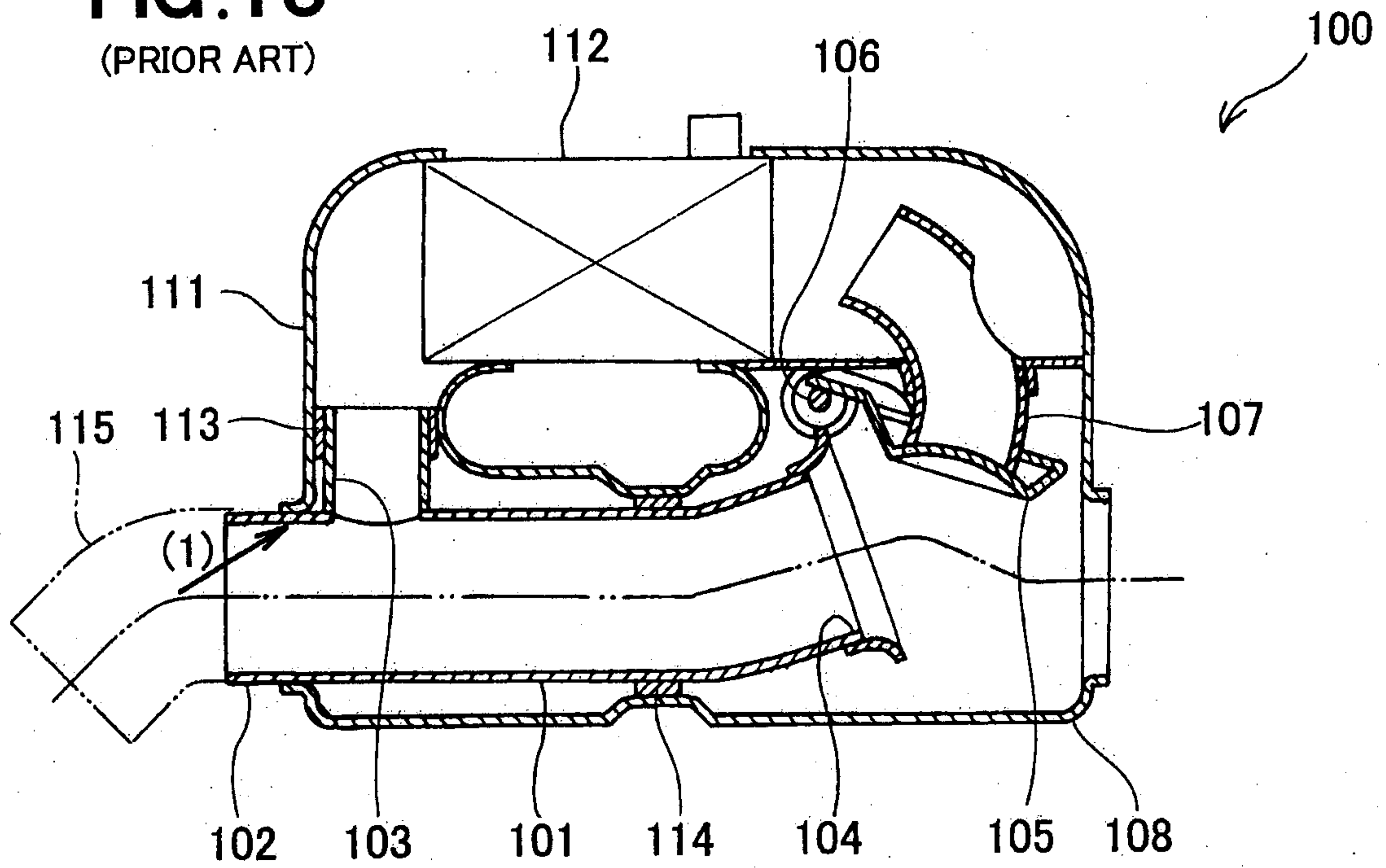
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FIG. 12



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FIG.13
(PRIOR ART)



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