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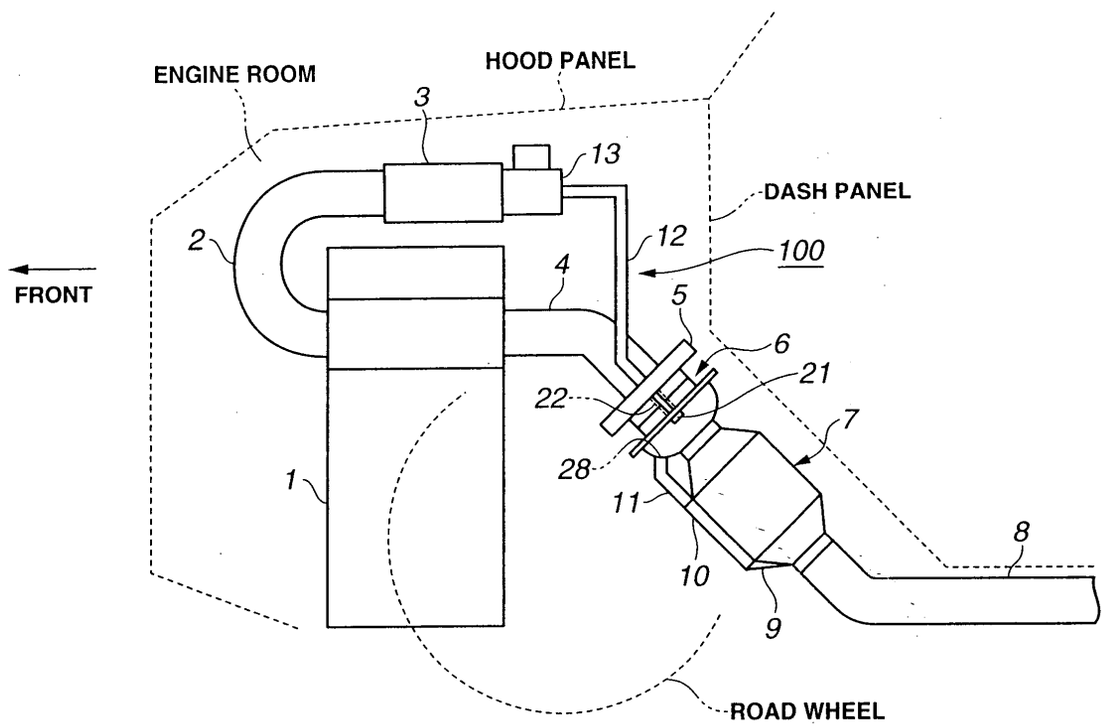
(54) Exhaust gas recirculation device of internal combustion engine

(57) An exhaust manifold of an internal combustion engine is pivotally connected to a catalytic converter through a spheric coupler. An exhaust gas recirculation device for use with the engine comprises an EGR gas inlet port provided in a downstream portion of the catalytic converter and an EGR gas passage line extending from the EGR gas inlet port to an intake system of the engine. At least a part of the EGR gas passage line is constructed by a passage defined in the spheric coupler.

FIG.1



EP 1 422 411 A2

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001] The present invention relates in general to exhaust gas recirculation (EGR) devices of an internal combustion engine and more particularly to the exhaust gas recirculation devices of a type which is compact in size, simple in construction and thus easy to be mounted on a limited space of an engine room of a motor vehicle.

2. Description of the Related Art

[0002] As is known, exhaust gas recirculation devices (or systems) are designed to circulate part of the exhaust gas into an intake system of the engine for lowering the combustion temperature of an air/fuel mixture in the engine thereby to reduce NOx emissions from the engine.

[0003] One of such exhaust gas circulation devices is shown in Laid-Open Japanese Utility Model Application (Jikkaihei) 1-78256, which is arranged to take the exhaust gas from an exhaust gas inlet port provided in the exhaust system downstream of a catalytic converter. In this type EGR device, the intake system of the engine can take therein a cleaned exhaust gas because the same has hydrocarbons and PM (viz., particulate matter) already removed by the catalytic converter. Thus, not only an EGR passage line of the EGR device, but also intake ports, intake valves, injectors, a throttle valve, etc., of the engine proper are protected from being contaminated by unwanted deposits.

[0004] In internal combustion engines having the above-mentioned EGR device, there is a type of employing an articulated coupler for pivotally connecting a catalytic converter to an exhaust manifold for the purpose of blocking undesired transmission of the vibration, pitching and/or rolling of the engine to the catalytic converter.

SUMMARY OF THE INVENTION

[0005] However, in the internal combustion engines of the above-mentioned type, usage of such articulated coupler, by which the catalytic converter is pivotally movable relative to the exhaust manifold, tends to induce a deformation of the longer EGR tube. Of course, when the deformation becomes marked, smoothed gas flow is not achieved in the EGR tube and thus in this case, satisfied performance of the EGR device is not expected. Furthermore, in the internal combustion engine of the type, layout of the EGR passage line of the EGR device has been given little thought. In fact, for just convenience sake, a longer EGR tube has been used which extends from the exhaust gas inlet port to the intake system of the engine running through a limited space defined in the engine room. As is known, such arrangement of the EGR device brings about a bulky and complicated construction of the same and thus makes the assembling work of the EGR device in the engine room difficult or at least troublesome.

[0006] It is therefore an object of the present invention to provide an exhaust gas recirculation device, which is free of the above-mentioned drawbacks.

[0007] According to a first aspect of the present invention, there is provided an exhaust gas recirculation device for use with an internal combustion engine which has a spheric coupler through which an exhaust manifold and a catalytic converter are pivotally connected, which comprises an EGR gas inlet port provided in a downstream portion of the catalytic converter; and an EGR gas passage line extending from the EGR gas inlet port to an intake system of the engine, wherein at least a part of the EGR gas passage line is constructed by a passage defined in the spheric coupler.

[0008] According to a second aspect of the present invention, there is provided an exhaust gas recirculation device for use with an internal combustion engine having an exhaust manifold to which a catalytic converter is pivotally connected through a spheric coupler, which comprises an EGR gas inlet port provided in an exhaust pipe downstream of the catalytic converter; a passage defined in the spheric coupler, the passage of the spheric coupler keeping its open condition even when the spheric coupler assumes a tilted position; a first EGR tube extending from the EGR gas inlet port to an inlet part of the passage of the spheric coupler; and a second EGR tube extending from an outlet part of the passage of the spheric coupler to an intake system of the engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009]

Fig. 1 is a schematic view of an engine room of a motor vehicle in which an exhaust gas recirculation device of a first embodiment of the present invention is practically mounted;

Fig. 2 is a sectional view of an exhaust manifold and a catalytic converter connected thereto, which are incorporated with the first embodiment;

Fig. 3 is a sectional view similar to Fig. 2, but showing the view taken from a different direction;

Fig. 4A is a sectional view of a major portion of a case of the catalytic converter;

Fig. 4B is an end view of an outlet defuser of the catalytic converter;

Fig. 5 is a sectional and exploded view of a spheric coupler and its associated parts, which are employed in the first embodiment;

Fig. 6A is a view taken from a direction of the arrow "C" of Fig. 5;

Fig. 6B is a view taken from a direction of the arrow "D" of Fig. 5;

Fig. 7A is a sectional view of the spheric coupler in an assembled condition;

Fig. 7B is a view similar to Fig. 7A, but showing a tilted condition of the spheric coupler; and

Fig. 8 is a view similar to Fig. 1, but showing an exhaust gas recirculation device of a second embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

[0010] In the following, two, viz., first and second embodiments 100 and 200 of the present invention will be described in detail with reference to the accompanying drawings.

[0011] For ease of understanding, various directional terms, such as right, left, upper, lower, rightward, etc., will be used in the following description. However, such terms are to be understood with respect to only a drawing or drawings on which the corresponding part or portion is shown.

[0012] Referring to Fig. 1, there is shown an exhaust gas recirculation device 100, which is the first embodiment of the present invention.

[0013] As shown in the drawing, mounted in an engine room of a motor vehicle is an internal combustion engine 1 which is of a transversely mounted type. An intake manifold 2 is connected to a front side of engine 1, and a collector unit 3 of intake manifold 2 is positioned above engine 1.

[0014] To a rear side of engine 1, there is connected an exhaust manifold 4 which has on a united downstream portion of branches thereof a flange 5. To flange 5, there is connected a catalytic converter 7 through a spheric coupler 6. Catalytic converter 7 has an outlet port (no numeral) from which an exhaust pipe 8 extends.

[0015] Due to usage of spheric coupler 6, relative pivoting between catalytic converter 7 and exhaust manifold 4 is permitted. Thus, swing movement of engine 1, which is inevitably produced under operation of the same, is appropriately absorbed by spheric coupler 6, and thus, catalytic converter 7 is suppressed from swinging largely. In fact, if the connection between exhaust manifold 4 and catalytic converter is tightly made without usage of such spheric coupler 6, the swing movement of engine 1 would induce a larger swinging of catalytic converter 7, which increases a possibility of bumping of catalytic converter 7 against the vehicle body. In case wherein an exhaust manifold is large in size and thus largely projected from the engine, such spheric coupler 6 is usually employed.

[0016] Referring back to Fig. 1, an EGR gas inlet port 9 is formed in a downstream part of catalytic converter 7. As will be described in detail hereinafter, EGR gas inlet port 9 is exposed to an EGR gas passage 10 that extends axially on and along a cylindrical case of catalytic converter 7. EGR gas passage 10 has an outlet from which a first EGR tube 11 extends to an EGR passage provided in spheric coupler 6. From the EGR passage of spheric coupler 6, there extends a second EGR tube 12 to the above-mentioned collector unit 3 through an EGR valve 13.

[0017] In the following, the pivotal connection between exhaust manifold 4 and catalytic converter 7 through spheric coupler 6 will be described in detail with reference to Figs. 2 and 3.

[0018] As shown, flange 5 connected to the downstream united portion of exhaust manifold 4 is formed with a smaller diameter tubular part 5a about which an annular gasket 14 is tightly disposed via press-fitting.

[0019] As will become apparent hereinafter, annular gasket 14 forms an essential element of spheric coupler 6 and has an open right end formed with a convex surface 14a.

[0020] Catalytic converter 7 comprises generally a cylindrical case 17, a catalyst support 15 installed in case 17, a holding mat 16 pressed between cylindrical case 17 and catalyst support 15, a conical inlet defuser 18 connected to an inlet end of case 17 and a conical outlet defuser 19 connected to an outlet end of case 17.

[0021] To conical inlet defuser 18, there is connected a flare flange unit 20 which forms another essential element of the above-mentioned spheric coupler 6 and has an open left part formed with a concave surface 20a which is intimately and slidably mated with convex surface 14a of annular gasket 14. It is now to be noted that due to the slidable contact between convex and concave surfaces 14a and 20a, a relative pivoting between annular gasket 14 and flare flange unit 20 is achieved.

[0022] A peripheral portion 20b of flare flange unit 20 is formed at its diametrically opposed portions with two bolt holes through which two threaded bolts 21 pass to loosely connect flare flange unit 20 to flange 5. That is, for this connection, each threaded bolt 21 is screwed into a threaded bore formed in flange 5, as shown. About each threaded bolt 21, there is disposed a coil spring 22 which is arranged to pull the peripheral portion 20b of flare flange unit 20 toward flange 5. Due to the work of the coil springs 22, concave surface 20a of flare flange unit 20 is biased against convex surface 14a of annular gasket 14 thereby to achieve an assured sealing therebetween.

[0023] Because of provision of the two bolts 21, flare flange unit 20 is caused to pivot relative to annular gasket 14 about an imaginary axis "L" (see Fig. 2) that connects the two bolts 21 while diametrically crossing flare flange unit 20. Due to this pivotal connection, vertical swing movement of exhaust manifold 4 and that of catalytic converter 7, which are inevitably caused by vertical vibration of engine 1, are assuredly and effectively absorbed.

[0024] In the following, the detail of catalytic converter 7 at a portion that constitutes a part of the exhaust gas recirculation device 100 will be described with reference to the drawings.

[0025] As is seen from Fig. 4A, cylindrical case 17 is produced by curving a single metal plate. That is, as is

understood from this drawing, the metal plate is pressed or curved to have a generally S-shaped cross section with a larger round upper part and a smaller rectangular lower part. Then, longitudinal flanged edges of the shaped metal plate are welded to predetermined portions "W". With these steps, there are defined a cylindrical exhaust gas chamber 17a which has catalyst support 15 (not shown in the drawing) received therein and an axially extending passage which constitutes the above-mentioned EGR gas passage 10. As shown, the EGR gas passage 10 extends in parallel with cylindrical exhaust gas chamber 17a and is isolated from the exhaust gas chamber 17a by a part 17b of case 17.

[0026] As is seen from Fig. 4B, conical outlet defuser 19 is produced by pressing a circular metal plate. Due to this pressing, a part of the metal plate is radially outwardly expanded to produce a radially expanded grooved portion 23 which serves as the above-mentioned EGR gas inlet port 9.

[0027] As is seen from Fig. 3, when conical outlet defuser 19 is properly connected to cylindrical case 17, an inside part of grooved expanded portion 23 is exposed to an open end of the EGR gas passage 10. Thus, upon proper connection, exhaust gas chamber 17a and EGR gas passage 10 become communicated to each other through grooved expanded portion 23 which serves as the EGR gas inlet port 9.

[0028] As is seen from Fig. 3, EGR gas passage 10 has a downstream open end 10a which is positioned radially outside of conical inlet defuser 18. From the downstream open end 10a, there extends first EGR tube 11 to spheric coupler 6.

[0029] As is seen from Fig. 1, when properly mounted in the exhaust system, the catalytic converter 7 is inclined in such a manner that its inlet port is positioned higher than its outlet port with respect to a road surface on which the associated motor vehicle stands. Due to this inclination of catalytic converter 7, EGR gas passage 10 inclines also, and thus, stagnation of condensed water in the passage 10 is prevented.

[0030] In the following, the detail of spheric coupler 6 at a portion that constitutes a part of the exhaust gas recirculation device 100 will be described with reference to Figs. 5, 6A, 6B, 7A and 7B.

[0031] As has been mentioned hereinafore, spheric coupler 6 comprises generally two parts which are, as is seen from Fig. 5, the annular gasket 14 and the flare flange unit 20 which are connected to each other through a so-called spherical bearing connection.

[0032] That is, annular gasket 14 is formed with convex surface 14a and flare flange unit 20 is formed with concave surface 20a. These convex and concave surfaces 14a and 20a are mated to intimately contact to each other. If desired, to the contrary, the convex surface may be provided by flare flange unit 20 and the concave surface may be provided by annular gasket 14.

[0033] As is seen from Figs. 5, 6A and 6B, annular gasket 14 is formed with two EGR passages 24 at diametrically opposed portions. Also flare flange unit 20 is formed with two EGR openings 25 at diametrically opposed portions.

[0034] As is seen from Fig. 2, these EGR passages 24 and openings 25 are mated with one another at the mutually contacting convex and concave surfaces 14a and 20a.

[0035] As is seen from this drawing, the two EGR openings 25 are exposed to a concave enclosed space 26 which is defined between an inner concave member 27a and an outer concave member 27b. As shown, outer member 27b is welded at its peripheral edge "W" to inner member 27a to constitute the flare flange unit 20.

[0036] As may be understood from Figs. 5, 7A and 7B, each of EGR openings 25 of flare flange unit 20 is so sized and shaped as to cover the entire area of the open end of the corresponding EGR passage 24 of annular gasket 14 even when flare flange unit 20 assumes a maximum angular position relative to annular gasket 14. In the illustrated embodiment, each open end of the EGR passages 24 and each EGR opening 25 are shaped elliptical.

[0037] As is seen from Figs. 2 and 7B, due to provision of two bolts 21 (see Fig. 2), flare flange unit 20 is permitted to pivot about the imaginary axis "L" (see Fig. 2) and thus can assume the maximum angular position that is denoted by reference "θ" in Fig. 7B.

[0038] As is seen from Figs. 6A and 6B, the open ends of EGR passages 24 of annular gasket 14 are positioned on the imaginary axis "L" and EGR openings 25 of flare flange unit 20 are also positioned on the imaginary axis "L". Due to this arrangement, relative displacement between the open ends of EGR passages 24 and their corresponding EGR openings 25 can be minimized, which can reduce the size of the open ends of EGR passages 24 and EGR openings 25.

[0039] Referring back to Figs. 2 and 3, concave enclosed space 26 of flare flange unit 20 is communicated with two EGR passages 24 of annular gasket 14 (see Fig. 2) as well as first EGR tube 11 (see Fig. 3) through an inlet opening 28 formed in outer concave member 27b of flare flange unit 20.

[0040] As is seen from Fig. 1, when exhaust gas recirculation device 100 is properly mounted in the engine room, inlet opening 28 is positioned at the lowermost portion of the outer concave member 27b with respect to a road surface on which the associated motor vehicle stands.

[0041] As is seen from Fig. 2, the flange 5 provided on the united downstream portion of exhaust manifold 4 is formed with two EGR passages 29 which are connected with the passages 24 of annular gasket 14 respectively. The EGR passages 29 are united and then connected to second EGR tube 12 for connecting with EGR valve 13 (see Fig. 1).

[0042] Thus, as is seen from Figs. 1, 2 and 3, EGR gas inlet port 9, EGR gas passage 10, first EGR tube 11, concave enclosed space 26, two EGR openings 25,

two EGR passages 24, two EGR passages 29 and second EGR tube 12 constitute a so-called "EGR gas passage line" that conveys a cleaned exhaust gas to the collector unit 3 through EGR valve 13.

[0043] In the following, operation of exhaust gas recirculation device 100 will be described with the aid of the drawings, especially Figs. 1, 2 and 3.

[0044] As is seen from Fig. 1, under operation of engine 1, exhaust gas from engine 1 is led into catalytic converter 7 through exhaust manifold 4 and spheric coupler 6. Thus, exhaust gas is treated and cleaned by catalytic converter 7 before being discharged to the open air through exhaust pipe 8.

[0045] During this, as is seen from Fig. 3, a part of the cleaned exhaust gas, that has passed through catalyst support 15 of catalytic converter 7, is led into EGR gas passage 10 from EGR gas inlet port 9 defined by conical outlet defuser 19. The cleaned exhaust gas is then led into first EGR tube 11, concave enclosed space 26 of flare flange unit 20, and then as is seen from Fig. 2, into EGR passages 24 of annular gasket 14 and into EGR passages 29 of the flange 5 and then, as is seen from Fig. 1, into second EGR tube 12 and finally led to the collector unit 3 through EGR valve 13. Due to the EGR gas recirculation as mentioned hereinabove, NOx emissions from the engine 1 can be reduced.

[0046] Now, advantages of the above-mentioned exhaust gas recirculation device of the first embodiment 100 will be described.

[0047] As is seen from Figs. 1 and 2, an intermediate part of the EGR gas passage line, that is the part constructed by concave enclosed space 26 of flare flange unit 20, EGR openings 25 of flare flange unit 20, and EGR passages 24 of annular gasket 14, is compactly and effectively provided by spheric coupler 6. That is, as is seen from Fig. 1, the fluid connection between first and second EGR tubes 11 and 12 is kept even when spheric coupler 6 shows its tilted condition (see Fig. 7B) due to an angled position of catalytic converter 7 relative to exhaust manifold 4.

[0048] Due to provision of spheric coupler 6 having the above-mentioned construction, vertical swing movement of exhaust manifold 4 and that of catalytic converter 7, which are inevitably produced by vertical vibration of engine 1, are assuredly and effectively absorbed while keeping the fluid connection between concave enclosed space 26 of flare flange unit 20 and each of EGR passages 24 of annular gasket 14. As may be understood from Figs. 1 and 7B, the pivotal movement between flare flange unit 20 and annular gasket 14 applies no stress to first and second EGR tubes 11 and 12 and thus deformation of these tubes 11 and 12, which would cause increase in gas flow resistance in the EGR gas passage line, is suppressed.

[0049] Spheric coupler 6 is of an articulated type comprising annular gasket 14 with convex surface 14a and flare flange unit 20 with concave surface 20a which intimately and slidably contacts the convex surface 14a. Annular gasket 14 is formed with EGR passages 24 and flare flange unit 20 is formed with EGR openings 25 mated with concave enclosed space 26. These EGR passages 24 and EGR openings 25 are mated at the area where convex surface 14a and concave surface 20a intimately contact. These arrangements bring about not only an assured pivotal connection between exhaust manifold 4 and catalytic converter 7 but also an assured constant fluid connection between first and second EGR tubes 11 and 12.

[0050] As is seen from Figs. 6A, 6B and 7B, each of EGR openings 25 of flare flange unit 20 is so sized and shaped as to cover the entire area of the open end of the corresponding EGR passage 24 of annular gasket 14 even when flare flange unit 20 is largely angled relative to annular gasket 14. Thus, EGR gas flow in the EGR gas passage line is smoothly and assuredly carried out even when a large relative angle is kept between flare flange unit 20 and annular gasket 14.

[0051] Due to provision of two bolts 21 (see Fig. 2) that loosely connect flare flange unit 20 to the flange 5 of the exhaust manifold 4, flare flange unit 20 is caused to pivot relative to annular gasket 14 about the imaginary axis "L". Accordingly, relative displacement between the open ends of EGR passages 24 of annular gasket 14 and their corresponding EGR openings 25 of flare flange unit 20 can be minimized, which can reduce the size of the open ends of EGR passages and EGR openings 25.

[0052] Since, as is seen from Fig. 2, two EGR passages 24 of annular gasket 14 and two EGR openings 25 of flare'flange unit 20 are provided at diametrically opposed positions of spheric coupler 6, not only a mechanically balanced construction of spheric coupler 6 but also a hydro-mechanically balanced flow of EGR gas is achieved in the EGR gas passage line.

[0053] As is seen from Fig. 3, the welded portions "W" of flare flange unit 20 are kept away from the mutually contacting convex and concave surfaces 14a and 20a of spheric coupler 6. Thus, the heat generated during the welding has substantially no influence on such surfaces 14a and 20a, and thus, a sealing ability possessed by the surfaces 14a and 20a is kept unchanged. Furthermore, because the welded portions "W" are exposed to the open area, the welding at such portions "W" is easily carried out.

[0054] Upon assembly of the exhaust gas recirculation device 100, the opening 28 of outer concave member 27b of flare flange unit 20 is positioned at the lowermost portion of the member 27b. Accordingly, condensed water inevitably produced in concave enclosed space 26 of flare flange unit 20 is smoothly drained therefrom, and thus, flare flange unit 20 is suppressed from having rust.

[0055] As is seen from Fig. 3, an upstream part of the EGR gas passage line, that is, the part constructed by EGR gas inlet port 9 and EGR gas passage 10, is neatly, compactly and integrally provided by case 17 of catalytic converter 7. Thus, as is seen from Fig. 1, the exhaust

gas recirculation device 100 can be simplified in construction and reduced in size. As is known, the exhaust gas recirculation device 100 having such features is easily mounted in an engine room even when the engine room has a limited space.

[0056] EGR gas inlet port 9 is provided by pressing a part of conical outlet defuser 19 (see Fig. 4B) and EGR gas passage 10 is provided by curving or pressing a single metal plate to have a generally S-shaped cross section (see Fig. 4A). Thus, the upstream part of the EGR gas passage line can be provided at a lower cost.

[0057] Since EGR gas inlet port 9 is positioned and constructed to receive a cleaned exhaust gas that has passed through catalytic converter 7, the interior of the EGR gas passage line is entirely protected from collecting unwanted deposits.

[0058] As is seen from Fig. 1, upon mounting on a motor vehicle, catalytic converter 7 is postured to incline with its inlet port positioned higher than its outlet port with respect to the road surface. Due to this inclination of catalytic converter 7, EGR gas passage 10 inclines also, and thus, stagnation of condensed water in the passage 10 is prevented. Thus, the passage 10 is protected from having rust.

[0059] Referring to Fig. 8, there is shown an exhaust gas recirculation device 200, which is a second embodiment of the present invention.

[0060] In this embodiment 200, there is no means that corresponds to the EGR gas passage (10) integrally provided by catalytic converter 7 employed in the above-mentioned first embodiment 100. That is, in this second embodiment 200, an EGR gas inlet port 31 is provided in exhaust pipe 8 downstream of catalytic converter 7, and an EGR tube 32 extends from EGR gas inlet port 31 to inlet opening 28 formed in outer concave member 27b of flare flange unit 20. Also in this embodiment 200, the fluid connection between the two EGR tubes 32 and 12 is assuredly kept even when spheric coupler 6 shows its tilted condition (see Fig. 7B) due to an angled position of catalytic converter 7 relative to exhaust manifold 4.

[0061] The entire contents of Japanese Patent Application 2002-340646 (filed November 25, 2002) are incorporated herein by reference.

[0062] Although the invention has been described above with reference to the embodiments of the invention, the invention is not limited to such embodiments as described above. Various modifications and variations of such embodiments may be carried out by those skilled in the art, in light of the above description.

Claims

1. An exhaust gas recirculation device (100, 200) for use with an internal combustion engine (1) which has a spheric coupler through which an exhaust manifold (4) and a catalytic converter (7) are pivotally connected, comprising:

an EGR gas inlet port (9, 31) provided in a downstream portion of the catalytic converter (7); and

an EGR gas passage line (10, 11, 24, 25, 26, 12, 32) extending from the EGR gas inlet port (9) to an intake system (3) of the engine (1),

wherein at least a part of the EGR gas passage line is constructed by a passage (24, 25, 26) defined in the spheric coupler (6).

2. An exhaust gas recirculation device as claimed in Claim 1, in which the spheric coupler comprises:

a first member (14) having a convex surface (14a) and connected to one (4) of the exhaust manifold (4) and the catalytic converter (7);

a second member (20) having a concave surface (20a) intimately contactable with the convex surface (14a) of the first member (14), the second member (20) being connected to the other (7) of the exhaust manifold (4) and the catalytic converter (7);

a first EGR passage (24) defined in the first member (14); and

a second EGR passage (25, 26) defined in the second member (20) and constantly exposed to the first EGR passage (24) of the first member (14).

3. An exhaust gas recirculation device as claimed in Claim 2, in which one of mutually facing open ends of the first and second EGR passages (24, 25, 26) is so sized and shaped as to cover the entire area of the other of the mutually facing open ends even when the first and second members (14, 20) show a maximum relative angle therebetween.

4. An exhaust gas recirculation device as claimed in Claim 3, in which the spheric coupler further comprises a pivot direction controller (21, 22) by which the second member (20) is permitted to pivot about a given axis relative to the first member (14), and in which the mutually facing ends of the first and second EGR passages (24, 25, 26) are positioned on the given axis.

5. An exhaust gas recirculation device as claimed in Claim 4, in which the pivot direction controller (21, 22) comprises:

two bolt holes formed in diametrically opposed portions of the second member (20);

two bolts (21) respectively passing through the two bolt holes to loosely connect the second member (20) to a member (5) fixed to the first member (14); and

two coil springs (22) respectively disposed

about the two bolts (21) to bias the concave surface (20a) of the second member (20) against the convex surface (14a) of the first member (14).

6. An exhaust gas recirculation device as claimed in Claim 2, in which each of the first and second EGR passages (24, 25, 26) comprises two passages that are provided at diametrically opposed positions of the spheric coupler.

7. An exhaust gas recirculation device as claimed in Claim 2, in which the second member (20) is a flare flange unit which comprises:

an inner concave member (27a) having the concave surface (20a) contactable with the convex surface (14a) of the first member (14);
an outer concave member (27b) welded at its peripheral edge to the inner concave member (27a) in a manner to define therebetween a concave enclosed space (26), the concave enclosed space (26) constituting the second EGR passage (25, 26) of the second member (20).

8. An exhaust gas recirculation device as claimed in Claim 7, in which the outer concave member (27b) is formed with an inlet opening (28) to which a tube (11, 32) connected to the EGR gas inlet port (9, 31) is connected.

9. An exhaust gas recirculation device as claimed in Claim 8, in which, upon assembly of the exhaust gas recirculation device (100, 200) in an engine room of a motor vehicle, the inlet opening (28) is positioned at the lowermost portion of the outer concave member (27b) with respect to a road surface on which the motor vehicle stands.

10. An exhaust gas recirculation device as claimed in Claim 1, further comprising an EGR gas passage (10) which is integrally formed on and along a side wall of the catalytic converter (7), the EGR gas passage (10) constituting at least a part of the EGR gas passage line.

11. An exhaust gas recirculation device as claimed in Claim 10, in which the EGR gas passage (10) extends along an axis of a case (17) of the catalytic converter (7), the case (17) having a catalytic support (15) installed therein, and in which the EGR gas passage (10) has an inlet part exposed to the EGR gas inlet port (9).

12. An exhaust gas recirculation device as claimed in Claim 11, in which the EGR gas passage (10) is integrally provided by the case (17) of the catalytic converter (7).

13. An exhaust gas recirculation device as claimed in Claim 12, in which the case (17) of the catalytic converter (7) is provided by pressing a metal plate to have a generally S-shaped cross section with a larger round upper part and a smaller rectangular smaller part, and welding given edges of the shaped metal plate, the shaped and welded metal plate constituting the EGR gas passage (10) at a portion that has the smaller rectangular lower part.

14. An exhaust gas recirculation device as claimed in Claim 13, in which the EGR gas inlet port (9) is defined by a radially expanded grooved portion (23) of an outlet defuser (19) of the catalytic converter (7), the groove of the radially expanded grooved portion (23) being exposed to the inlet part of the EGR gas passage (10).

15. An exhaust gas recirculation device as claimed in Claim 1, in which, upon assembly of the exhaust gas recirculation device (100, 200) in an engine room of a motor vehicle, the catalyst converter (7) is inclined in such a manner that its inlet port is positioned higher than its outlet port with respect to a road surface on which the motor vehicle stands.

16. An exhaust gas recirculation device (200) for use with an internal combustion engine (1) having an exhaust manifold (4) to which a catalytic converter (7) is pivotally connected through a spheric coupler (6), comprising:

an EGR gas inlet port (9) provided in an exhaust pipe (8) downstream of the catalytic converter (7);
a passage (24, 25, 26) defined in the spheric coupler (6), the passage of the spheric coupler keeping its open condition even when the spheric coupler (6) assumes a tilted position;
a first EGR tube (32) extending from the EGR gas inlet port (9) to an inlet part of the passage (24, 25, 26) of the spheric coupler (6); and
a second EGR tube (12) extending from an outlet part of the passage (24, 25, 26) of the spheric coupler (6) to an intake system (3) of the engine (1).

FIG.1

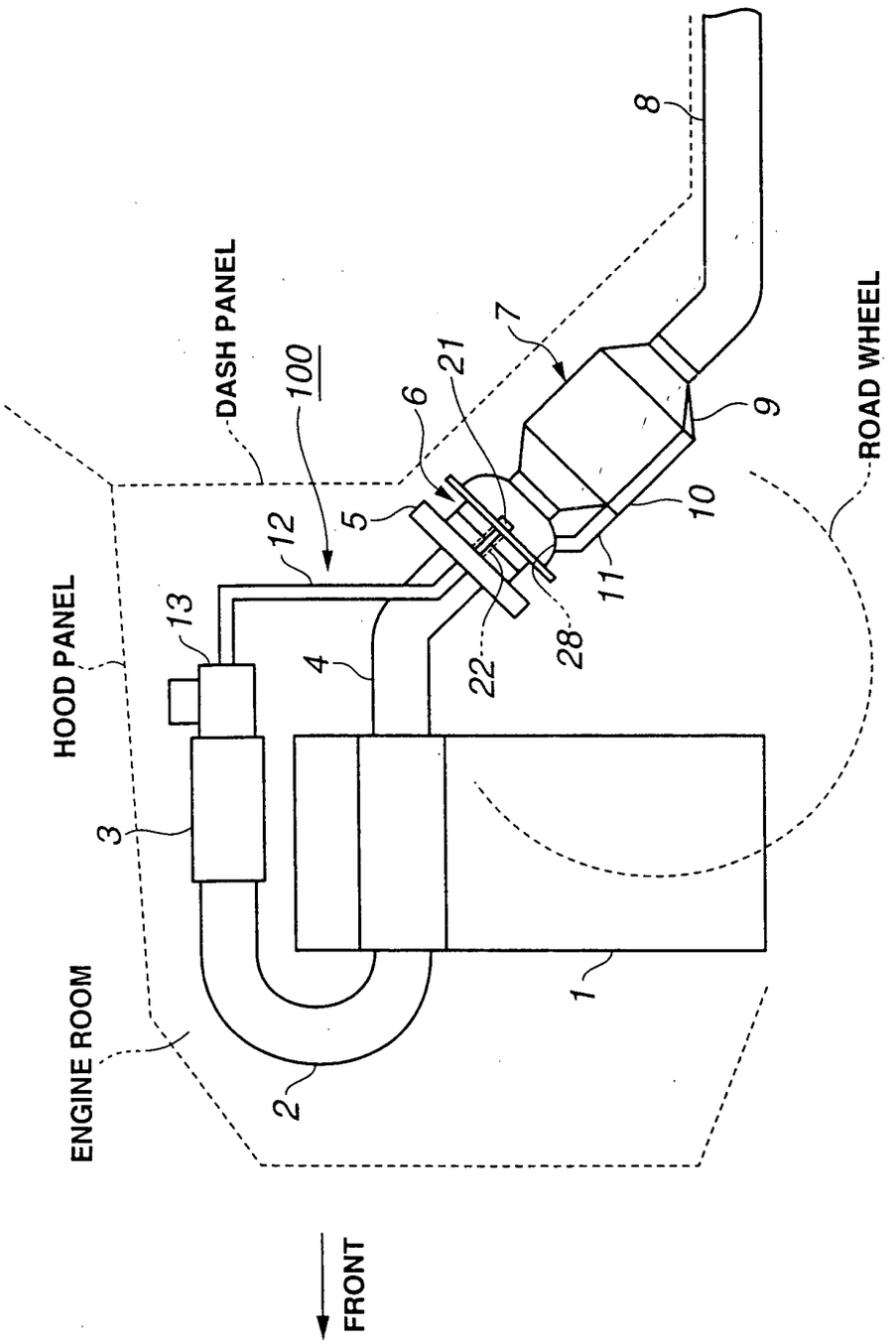

DASH PANEL
100
HOOD PANEL
ENGINE ROOM
ROAD WHEEL
FRONT
1
2
3
4
5
6
7
8
9
10
11
12
13
21
22
28

FIG.2

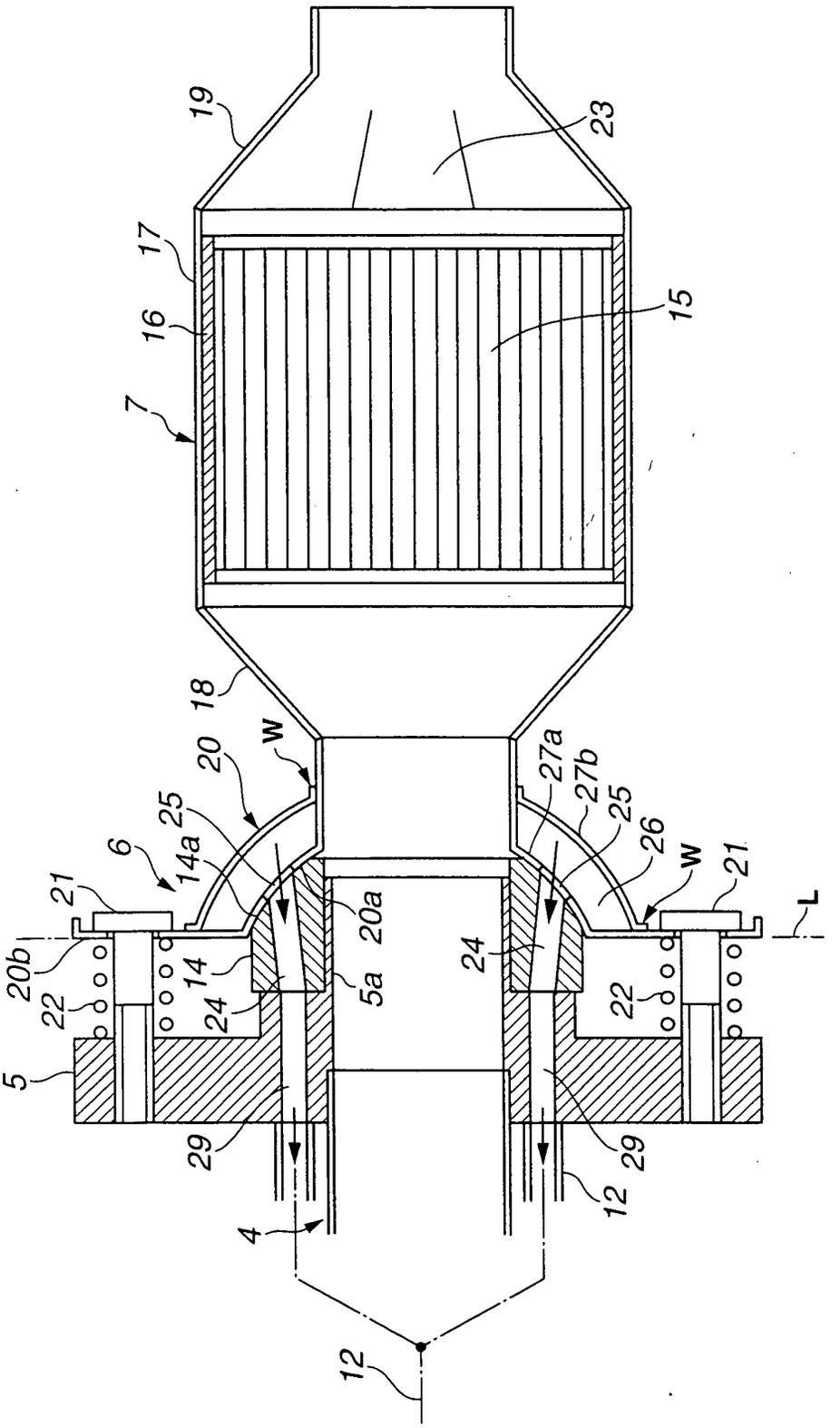

19
23
17
16
15
7
18
W
20
27a
27b
25
25
6
14a
26
W
21
21
L
20a
20b
14
24
24
22
22
5a
5
29
29
12
4
12

FIG.3

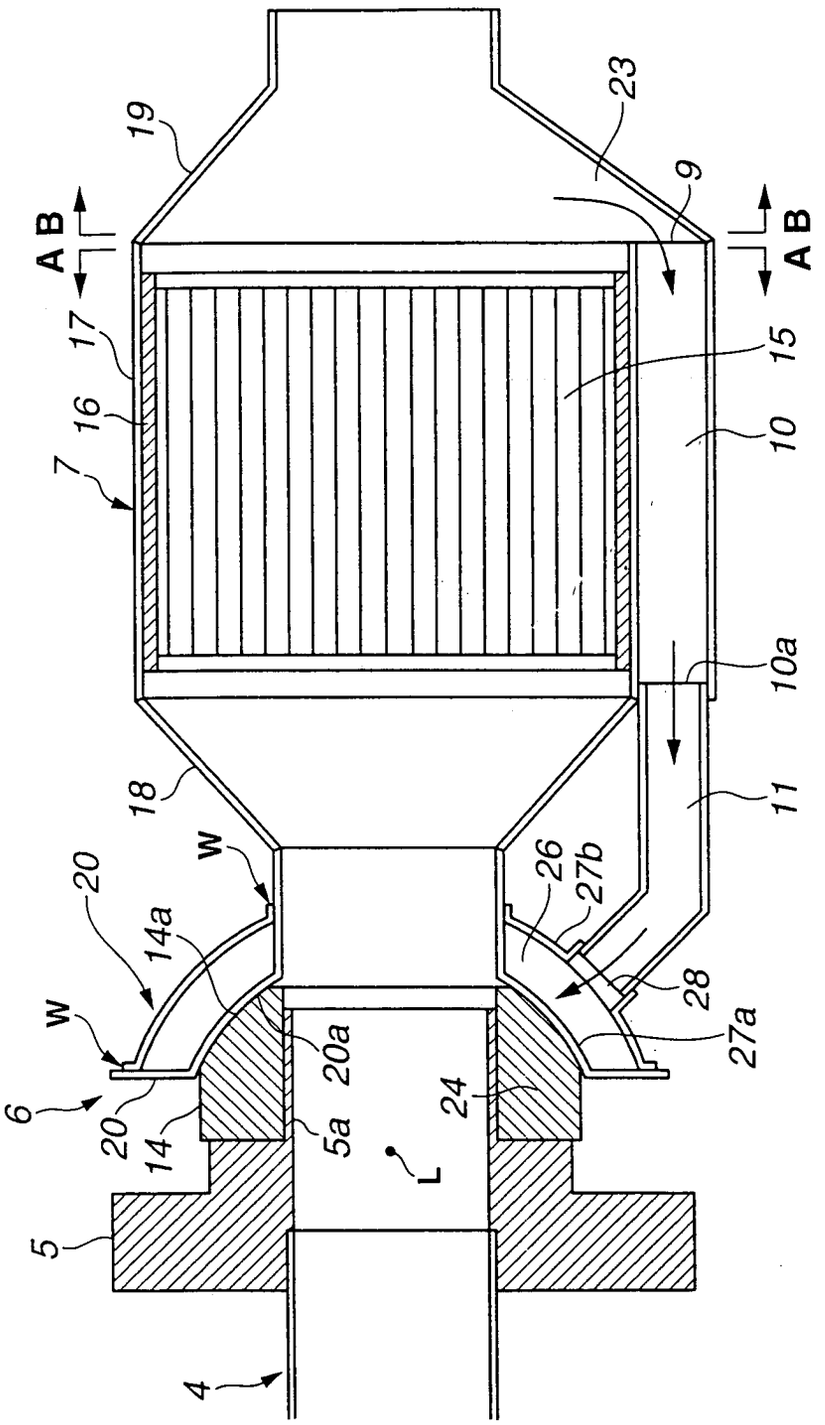

19
23
9
A
B
A
B
17
16
7
15
10
10a
11
18
W
20
14a
26
27b
28
W
27a
20a
6
20
14
5a
24
L
5
4

FIG.4B

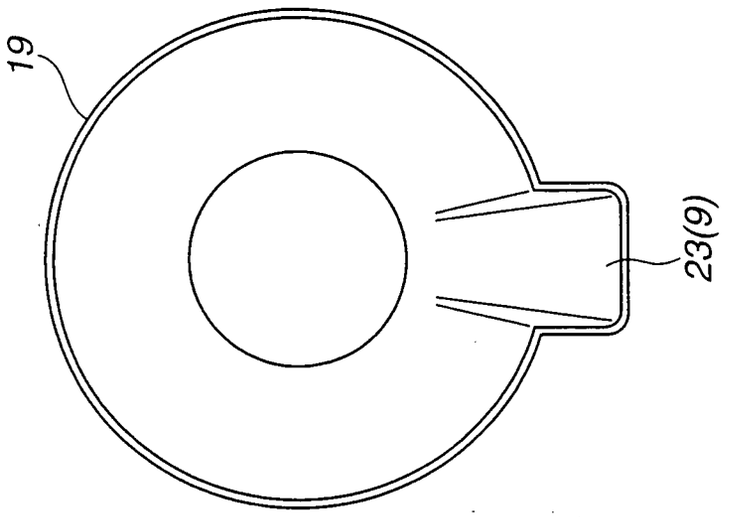


FIG.4A

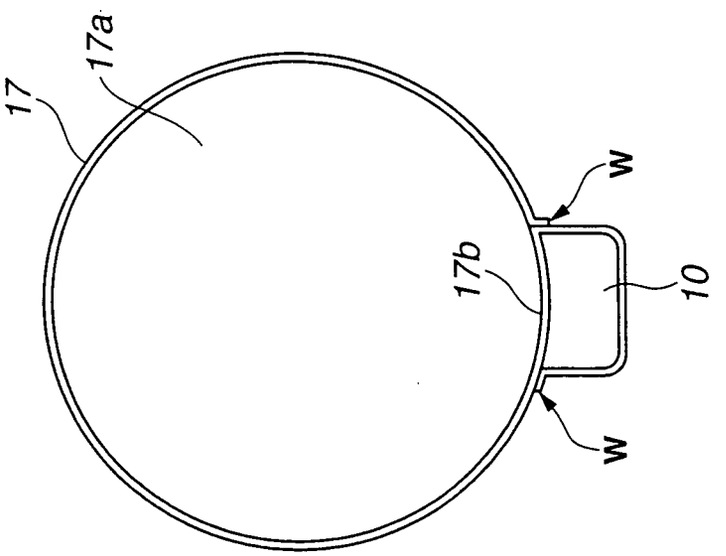


FIG.5

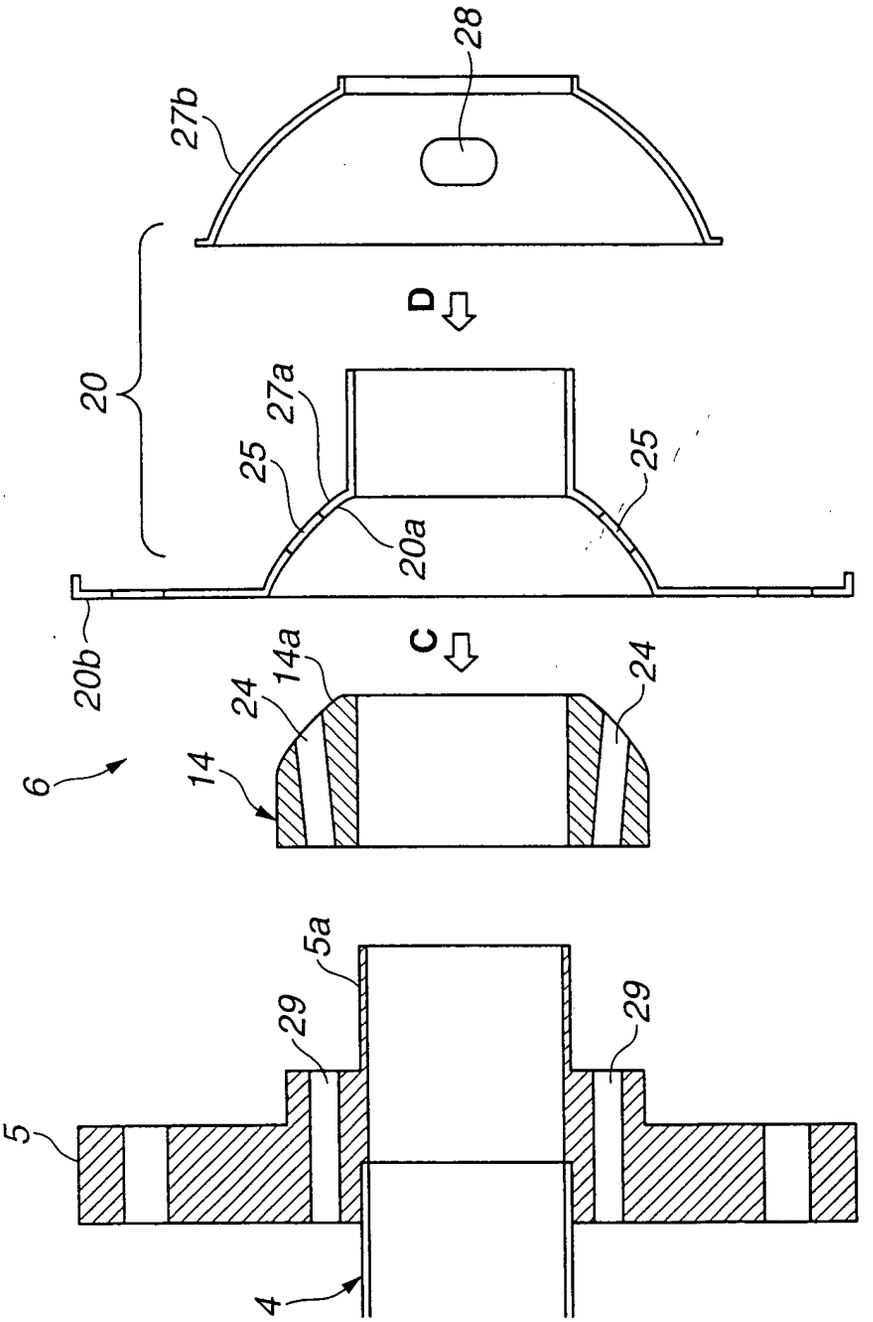


FIG.6B

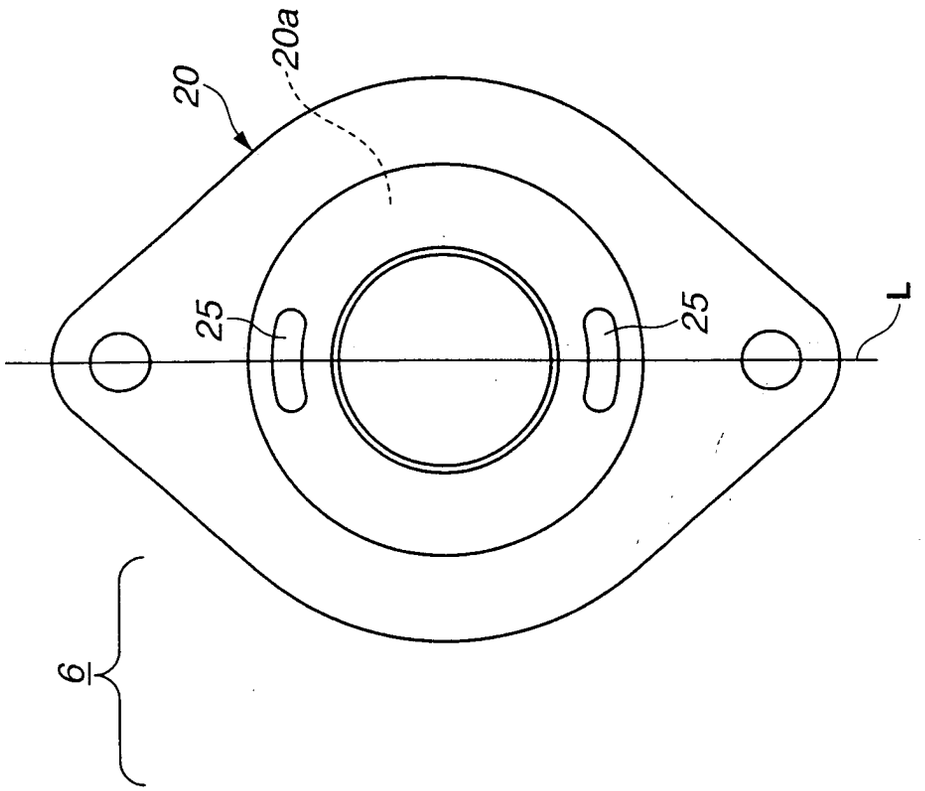


FIG.6A

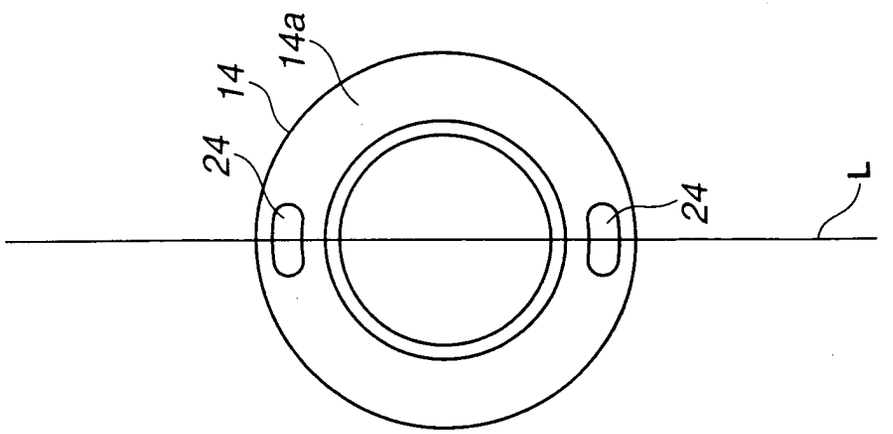


FIG.7B

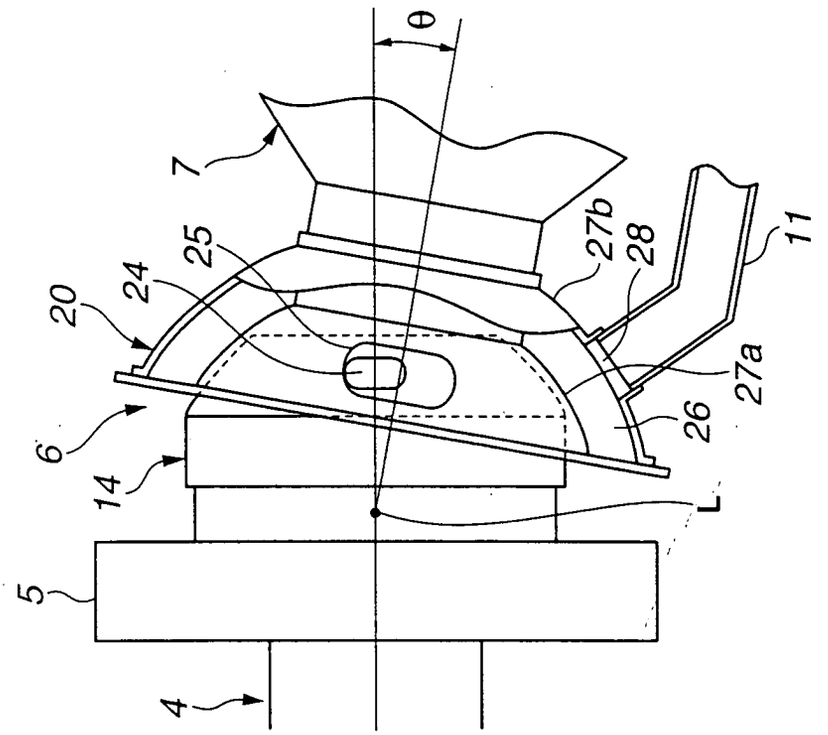

θ
7
27b
28
11
25
24
20
27a
26
6
14
L
5
4

FIG.7A

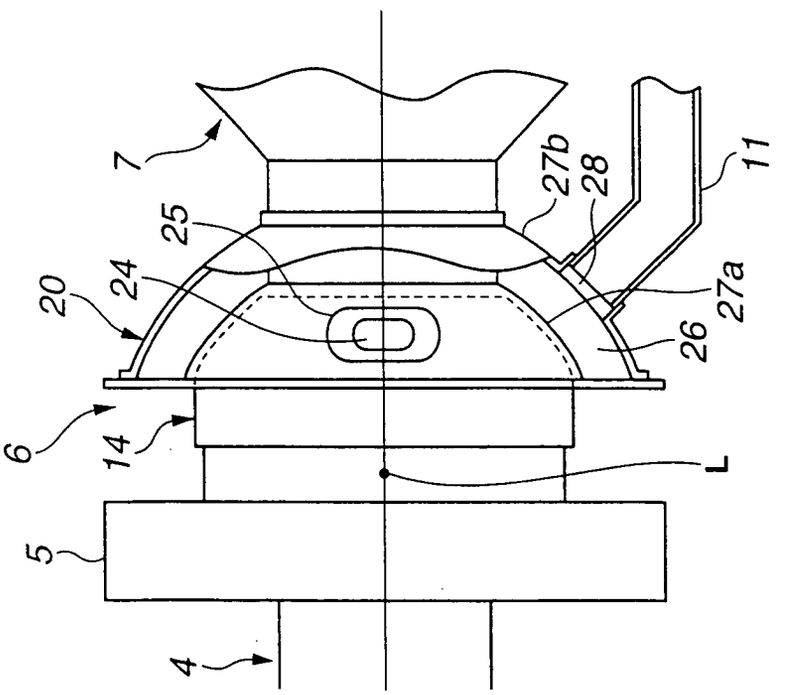
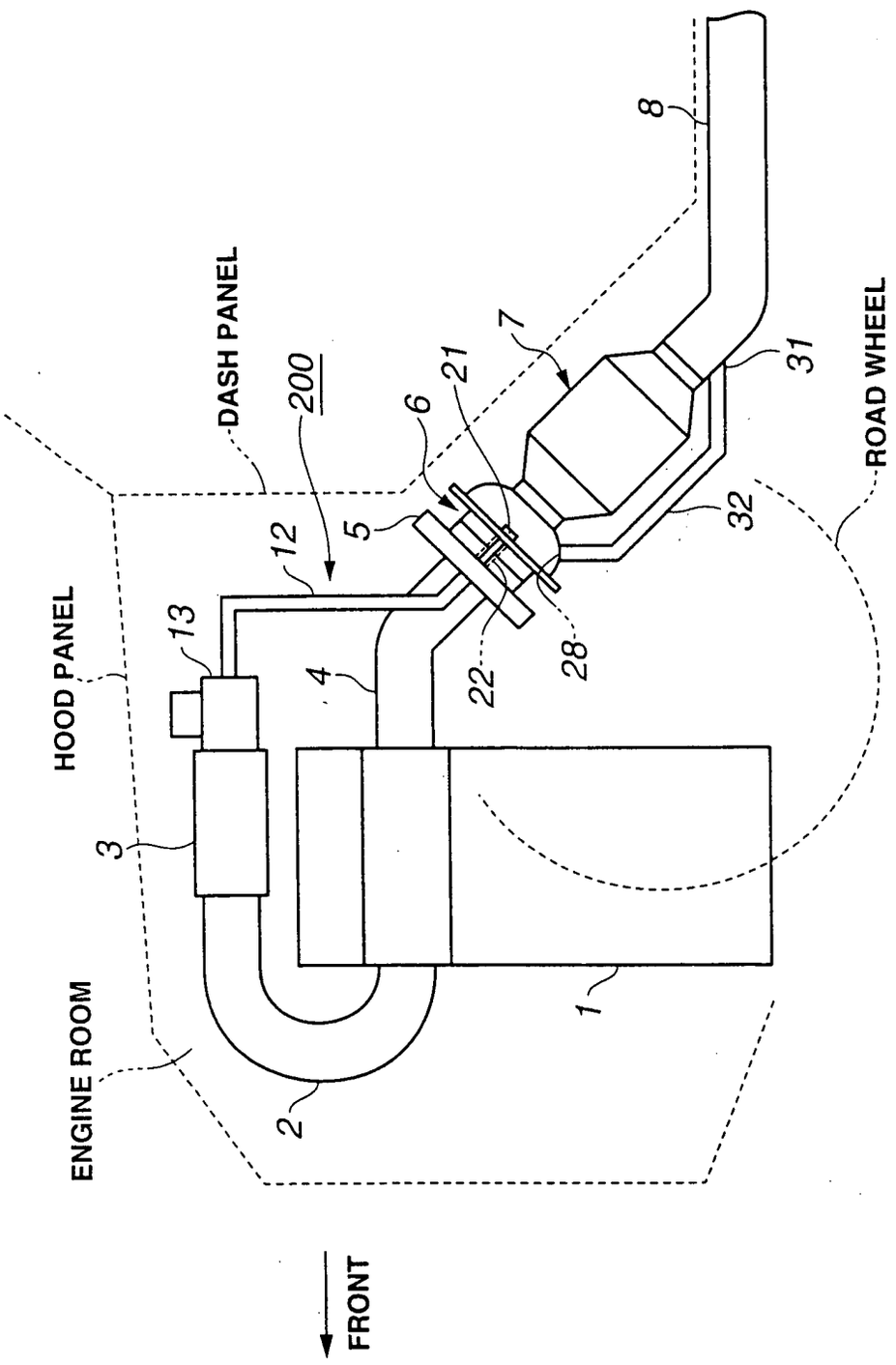

7
27b
28
11
25
20
24
27a
26
6
14
L
5
4

FIG.8


DASH PANEL
200
HOOD PANEL
ENGINE ROOM
ROAD WHEEL
FRONT
1
2
3
4
5
6
7
8
12
13
21
22
28
31
32