(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 322 787 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
18.05.2011 Bulletin 2011/20

(51) Int Cl.:
F02M 25/07 *(2006.01)*

(21) Application number: **10190514.9**

(22) Date of filing: **09.11.2010**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **12.11.2009 JP 2009259242**

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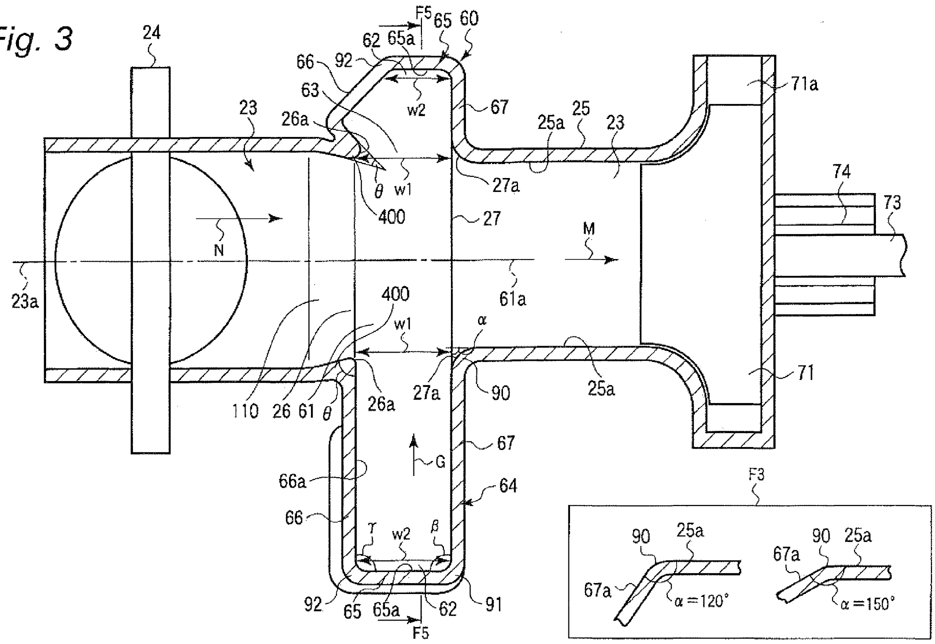
(54) Exhaust gas recirculation system

(57) An exhaust gas recirculation system includes an induction passageway (23) through which fresh air flows and an annular flow path (62) extending in a circumferential direction of the induction passageway (23) and formed in an annular shape. The annular flow path (62) encompasses the induction passageway (23) therein. An inlet port (63) is formed between the induction passageway (23) and the annular flow path (62) and communicates the induction passageway with the annular flow path. An exhaust gas introduction flow path (80) is communicated with the annular flow path (62) and introduces the exhaust gases into the annular flow path (62) so that the exhaust gases flow in one direction of the circumferential direction. The annular flow path (62) has an inner face facing the inlet port (63), and the inner face has a width (w2) in a direction crossing the one direction. An upstream side of the width (w2) is shorter than a downstream side of the width (w2) with respect to a flow of the exhaust gasses which flows into the annular flow path (62) from the exhaust gas introduction flow path (80).

Fig. 3



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Description

BACKGROUND

[0001] The present invention relates to the technology of exhaust gas recirculation systems for introducing exhaust gases into an induction system.

[0002] Conventionally, exhaust gas recirculation systems have been proposed for returning a portion of exhaust gases to an induction system to improve the fuel economy in a low-load region of an engine and reduce oxides of nitrogen (NOx). The exhaust gas recirculation system includes a recirculation passageway which induces exhaust gases to enter the induction system. The recirculation passageway is connected to an induction passageway through which fresh air flows in the induction system.

[0003] Fresh air mixes with EGR (Exhaust Gas Recirculation) gases at a connecting portion between the induction passageway and the recirculation passageway. A mixture of fresh air and EGR gases flows downstream of the connecting portion. The connecting construction between the induction passageway and the recirculation passageway will specifically be described. An induction pipe which configures the induction passageway and a recirculation passageway pipe are connected to each other. The recirculation passageway pipe is connected to the induction pipe so as to strike it from a side thereof. Therefore, EGR gases supplied from the recirculation passageway are supplied from one side portion of the induction pipe.

[0004] As a result, EGR gases are made difficult to be dispersed into the induction passageway in a region lying just downstream of the connecting portion. By EGR gas being made difficult to be dispersed within the induction passageway there is caused a state in which fresh air is separated from EGR gases in the induction passageway. Therefore, the flow velocity distribution of the mixture of fresh air and EGR gases which flow within the induction passageway does not become uniform within the section of the same flow path at a portion lying just downstream of the connecting portion.

[0005] For example, in a construction in which the connecting portion between the induction passageway and the recirculation passageway is disposed just upstream of a compressor of a turbo charger, in the event that the flow velocity distribution is not uniform within the section of the flow path at the portion lying just downstream of the connecting portion, a pressure applied to the compressor by the mixture of fresh air and EGR gases striking differs from portion to portion.

[0006] As a result, since a force in the direction which passes across a rotating shaft of the compressor is applied to the compressor, it is considered that the compressor contacts a housing which accommodates the compressor, whereby wear attributed to the contact and wear between the rotating shaft and bearings are generated, leading to the failure of the compressor.

[0007] Because of this, in order that EGR gases are dispersed even at the portion lying just downstream of the connecting portion between the recirculation passageway and the induction passageway so that the flow velocity distribution within the section of the flow path becomes uniform thereat, there is proposed a technology in which an annular path is formed on the circumference of an induction passageway through which fresh air flows so as to surround the induction passageway so that EGR gases are introduced into the induction passageway from a circumferential direction through the annular path.

[0008] In this type of technology, a hole is formed between the induction passageway and the annular path, and the induction passageway communicates with the annular path through the hole. A recirculation passageway is connected to the annular path, whereby EGR gases are introduced thereinto. The EGR gases so introduced into the annular path are introduced into the induction passageway in the circumferential direction through the hole (refer to Patent Document 1).

[0009] There is proposed a technology in which a flow path through which EGR gases flow is formed on an outer side of an induction passageway so as to extend in a circumferential direction of the induction passageway and EGR gases which have passed through the flow path are introduced into the induction passageway along the direction of a tangent to the induction passageway. A communication hole is formed between the flow path through which EGR gases flow and the induction passageway, so that EGR gases are also introduced into the induction passageway through the communication hole (refer to Patent Document 2).

[Patent Document 1] Japanese Utility Model Publication Number 3-114564
[Patent Document 2] Japanese Patent Publication Number 2000-161147

SUMMARY

[0010] In the constructions described in Patent Documents 1, 2 in which the flow path through which EGR gases flow is formed on the outer side of the induction passageway so as to extend along the circumferential direction of the induction passageway and EGR gases are introduced into the induction passageway through the hole having the constant diameter which is formed between the flow path and the induction passageway, in the event that the flow rate of EGR gases is low, it is considered that the amount of EGR gases which are introduced into the induction passageway from the hole becomes uneven depending on positions around the hole whereby fresh air and EGR gases are made difficult to mix with each other evenly. On the other hand, in the event that the flow rate of EGR gases is high, the flow of EGR gases is disturbed, which increases the induction resistance of EGR gases. As a result, it is considered that EGR gases are made difficult to be introduced into the induction passageway.

[0011] An object of the invention is to provide an exhaust gas recirculation system which can suppress the generation of unevenness in flow velocity distribution in a section of a flow path of an induction passageway even just downstream of a connecting portion between the induction passageway and a recirculation passageway while introducing exhaust gases into an interior of the induction passageway with good efficiency.

[0012] According to an aspect of the invention, there is provided an exhaust gas recirculation system comprising an induction passageway through which fresh air flows;

an annular flow path extending in a circumferential direction of the induction passageway and formed in an annular shape, the annular flow path encompassing the induction passageway therein;

an inlet port formed between the induction passageway and the annular flow path and communicating the induction passageway with the annular flow path; and

an exhaust gas introduction flow path communicated with the annular

flow path and configured to introduce the exhaust gases into the annular flow path so that the exhaust gases flow in one direction of the circumferential direction, wherein the annular flow path has an inner face facing the inlet port, the inner face has a width in a direction crossing the one direction, and

an upstream side of the width is shorter than a downstream side of the width with respect to a flow of the exhaust gasses which flows into the annular flow path from the exhaust gas introduction flow path.

[0013] The exhaust gas recirculation system may be configured such that: a first inner wall surface of the annular flow path which defines an upstream side opening edge of the inlet port at an upstream side of the introduction passageway intersects with an inner wall surface of the introduction passageway at a first angle, a second inner wall surface of the annular flow path which defines a downstream side opening edge of the inlet port at a downstream side of the introduction passageway intersects the inner wall surface of the introduction passageway at a second angle, and the second angle is larger than the first angle.

[0014] The exhaust gas recirculation system may be configured such that a constriction portion which decreases a flow path sectional area of the induction passageway is formed at the upstream side opening edge of the inlet port at an upstream side of the introduction passageway.

[0015] The exhaust gas recirculation system may be configured such that a width of the inlet port in the direction crossing the one direction of the annular flow path becomes longer as the inlet port extends downstream along the one direction.

[0016] The exhaust gas recirculation system may be configured such that a flow path section of the annular flow path crossing the one direction of the annular flow path is made smaller as the annular flow path extends downstream along the one direction.

[0017] According to the invention, exhaust gases are introduced evenly from the circumferential direction of the induction passageway while introducing exhaust gases into the induction passageway with good efficiency, whereby the unevenness in the flow velocity distribution in the flow path section is suppressed even just downstream of the connecting portion between the induction passageway and the recirculation passageway.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018]

Fig. 1 is a schematic diagram showing an engine system which includes an exhaust gas recirculation system according to a first embodiment of the invention.

Fig. 2 is a perspective view showing a connecting portion shown in Fig. 1 and a portion of an induction system which lies in the vicinity of the connecting portion.

Fig. 3 is a sectional view taken along the line F3-F3 shown in Fig. 2 which shows the connecting portion and the portion of the induction system which lies in the vicinity of the connecting portion.

Fig. 4 is a perspective view showing the connecting portion which is sectioned in the same way as Fig. 3 and the portion of the induction system which lies in the vicinity of the connecting portion in a partially cutaway fashion.

Fig. 5 is a sectional view of the connecting portion which is taken along the line F5-F5 shown in Fig. 3.

Fig. 6 is a schematic diagram showing in a partially cutaway fashion a section of a flow path defined within an annular flow path shown in Fig. 1 which is taken along a direction which extends across a circumferential direction.

Fig. 7 is a side view of a portion of an induction passageway shown in Fig. 1 which lies in the vicinity of a throttle valve as viewed from a side thereof.

Fig. 8 is a sectional view of a connecting portion and portions lying in the vicinity of the connecting portion of an engine system including an exhaust gas recirculation system according to a second embodiment of the invention, the sectional view being taken along a plane which passes through an axis of a main flow path and a first position.

Fig. 9 is a schematic diagram showing a section of a flow path defined within an annular flow path shown in Fig. 8 which is taken along a direction which extends across a circumferential direction.

Fig. 10 is a sectional view of a connecting portion and a portion lying in the vicinity of the connecting portion of an engine system which includes an exhaust gas recirculation system according to a third embodiment of the invention.

DETAILED DESCRIPTION OF EXEMPLIFIED EMBODIMENTS

[0019] An exhaust gas recirculation system according to a first embodiment of the invention will be described by use of Figs. 1 to 7. An exhaust gas recirculation system of this embodiment is used in an engine system 10 which includes a reciprocating diesel engine 11 as an example. The engine system 10 is mounted in a motor vehicle, which is not shown.

[0020] Fig. 1 is a schematic diagram showing the engine system 10. As is shown in Fig. 1, the engine system 10 includes the reciprocating diesel engine 11, an induction system 20 for introducing intake air into the diesel engine 11, an exhaust system 30 for introducing exhaust gases discharged from the diesel engine 11 to the outside of the motor vehicle and a turbocharger 70.

[0021] In this embodiment, the diesel engine 11 is made up of a cylinder block 12, a cylinder head 13 and the like and constitutes a portion of the engine system 10 which excludes an induction passageway (part of the induction system 20) for introducing intake air into cylinders 14 and an exhaust passageway (part of the exhaust system 30) for introducing exhaust gases discharged from the cylinders 14 to the outside of the engine.

[0022] The induction system 20 includes an air cleaner 21, an intercooler 22, a throttle valve 24, and an induction passageway 23 which connects the air cleaner 21, the intercooler 22 and the cylinders 14 for introducing intake air into the cylinders 14. The air cleaner 21 is disposed upstream of the induction passageway 23 and communicates with the induction passageway 23. Air (fresh air) which has passed through the air cleaner 21 is introduced into the induction passageway 23 so as to be then introduced into the diesel engine 11. The intercooler 22 is disposed downstream of the air cleaner 21 in the induction passageway 23.

[0023] A compressor 71 (shown in Fig. 3) of the turbocharger 70 is provided between the air cleaner 21 and the intercooler 22 in the induction passageway 23. The throttle valve 24 is provided between the air cleaner 21 and the compressor 71 in the induction passageway 23. The induction passageway 23 is formed of a tubular member 25, for example.

[0024] The exhaust system 30 includes an exhaust passageway 31, a catalytic converter 32, a filter 33, a high-pressure EGR (Exhaust Gas Recirculation) system 40, and a low-pressure EGR (Exhaust Gas Recirculation) system 50. The exhaust passageway 31 communicates with the respective cylinders 14 of the diesel engine 11 so as to introduce exhaust gases G discharged from the respective cylinders 14 to the outside. A turbine 72 of the turbocharger 70 is provided in the exhaust passageway 31.

[0025] The catalytic converter 32 and the filter 33 are provided in the exhaust passageway 31 and are disposed downstream of the turbine 72. The catalytic converter 32 includes an oxidizing catalyst, for example, which oxidizes carbon monoxides (CO) and hydrocarbons (HC) which are contained in exhaust gases G. The filter 33 is disposed downstream of the catalytic converter 32. The filter 33 captures particulate matters contained in exhaust gases G.

[0026] The exhaust passageway 31 is formed of a tubular member 34, for example. The tubular member 34 connects the respective constituent components of the exhaust system 30 which include the turbine 72, the catalytic converter 32 and the filter 33 for introduction of exhaust gases G to the outside.

[0027] The high-pressure EGR system 40 includes a high-pressure EGR recirculation passageway 41, a high-pressure EGR catalytic converter 42, and a high-pressure EGR valve 43. The high-pressure EGR recirculation passageway 41 connects a position on the exhaust passageway 31 which lies upstream of the turbine 72 and a position on the induction passageway 23 which lies downstream of the intercooler 22 for communication.

[0028] The high-pressure EGR catalytic converter 42 is provided in the high-pressure EGR recirculation passageway 41. The high-pressure EGR catalytic converter 42 captures deposits contained in exhaust gases G which flow into the high-pressure EGR recirculation passageway 41.

[0029] The high-pressure EGR valve 43 is provided at a connecting portion between the high-pressure EGR recirculation passageway 41 and the induction passageway 23 and is adapted to open and close a high-pressure EGR induction port 44 which establishes a communication between the high-pressure EGR recirculation passageway 41 and the induction passageway 23. The high-pressure EGR valve 43 is controlled by a control unit, not shown, for example, so as to be opened or closed or so that the opening of the same valve is adjusted in accordance with an amount of EGR gases required.

[0030] The low-pressure EGR system 50 is an example of an exhaust gas recirculation system according to the subject patent application. The low-pressure EGR system 50 includes a low-pressure EGR recirculation passageway 51, an EGR cooler 52, and a low-pressure EGR valve 300. The low-pressure recirculation passageway 51 is connected to the exhaust passageway 31 in a position downstream of the filter 33 and the induction passageway 23 in a position lying between the throttle valve 24 and the compressor 71 and establishes a communication between the exhaust passageway 31 and the induction passageway 23. The EGR cooler 52 is provided in the low-pressure EGR recirculation passageway 51.

[0031] The low-pressure EGR valve 300 is provided downstream of the EGR cooler 52 in the low-pressure EGR recirculation passageway 51 (in an exhaust gas introduction flow path 80, which will be described later, in this embodiment) so as to open and close the low-pressure EGR recirculation passageway 51. When the low-pressure EGR valve 300 opens, the low-pressure EGR recirculation passageway 51 opens, whereby exhaust gases G are introduced into the induction passageway 23. When the low-pressure EGR valve 300 closes, the low-pressure EGR recirculation passageway 51 closes, whereby exhaust gases G are not introduced into the induction passageway 23.

[0032] The low-pressure EGR recirculation passageway 51 includes a connecting portion 60 which connects to the induction passageway 23 and the exhaust gas introduction 80 which connects to the exhaust passageway 31 so as to introduce exhaust gases G into the connecting portion 60.

[0033] In Fig. 1, a range F1 defined by a chain double-dashed line includes the connecting portion 60 and a portion which lies in the vicinity of the connecting portion in the induction system 20. Fig. 2 is a perspective view showing, in a partially cutaway fashion, the connecting portion 60 and the portion lying in the vicinity of the connecting portion 60 in the induction system 20.

[0034] As is shown in Figs. 1, 2, the connecting portion 60 is provided between the throttle valve 24 and the compressor 71 in the induction passageway 23. Fig. 3 is a sectional view taken along the line F3-F3 shown in Fig. 2 which shows the connecting portion 60 and the portion of the induction system 20 which lies in the vicinity of the connecting portion 60. Fig. 4 is a perspective view showing the connecting portion 60 which is sectioned in the same way as Fig. 3 and the portion of the induction system which lies in the vicinity of the connecting portion. Fig. 5 is a sectional view of the connecting portion 60 which is taken along the line F5-F5 shown in Fig. 3.

[0035] As is shown in Figs. 2 to 4, the connecting portion 60 encompasses the induction passageway 23 circumferentially therein. The connecting portion 60 includes a main flow path 61 which constitutes part of the induction passageway 23 and an annular flow path 62 which is formed along a circumference of the main flow path 61 so as to communicate with the main flow path 61. The main flow path 61 is an example of a main flow path of the invention. The annular flow path 62 is an example of an annular flow path of the invention.

[0036] As is shown in Fig. 5, the annular flow path 62 is formed along a circumferential direction of the main flow path 61 so as to encompass the main flow path 61 therein. The annular flow path 62 is formed in an annular fashion so as to extend along a circumferential direction A of the main flow path 61. The circumferential direction is indicated by arrows in the figure.

[0037] An inlet port 63 is formed between the main flow path 61 and the annular flow path 62. The main flow path 61 and the annular flow path 62 communicate with each other via the inlet port 63. The inlet port 63 is formed annularly along the circumferential direction A of the main flow path 61. Namely, the inlet port 63 is formed over a whole circumferential area of the main flow path 61. Because of this, the main flow path 61 and the annular flow path 62 communicate with each other in an annular fashion in the circumferential direction A of the main flow path 61. In other words, the main flow path 61 and the annular flow path 62 communicate with each other over the whole circumferential area of the main flow path 61. The inlet port 63 is an example of an inlet port of the invention.

[0038] The annular flow path 62 will be described specifically. As is shown in Fig. 3, the annular flow path 62 is defined by an inner surface of an outer circumferential wall portion 64. The outer circumferential wall 64 has a bottom wall portion 65 which faces the inlet port 61, an upstream-side side wall portion 66 which faces an upstream side of the main flow path 61 and a downstream-side side wall portion 67 which faces a downstream side of the main flow path 61. The bottom wall portion 65 is formed into a moderate annular shape which extends along the circumferential direction A of the main flow path 61 so as to encompass the main flow path 61 therein.

[0039] The upstream-side side wall portion 66 connects to an upstream-side edge of the bottom portion 65 and is integral therewith. In addition, the upstream-side side wall portion 66 is positioned further upstream than the main flow path 61 in the induction passageway 23 and connects to an edge 26a of a first communication port 26 which communicates with the main flow path 61. Additionally, a constriction portion 110 is formed in the induction passageway 23 in a position lying just upstream of the edge 26a so as to connect to the edge 26a. The constriction portion 110 decreases the flow path sectional area of the induction passageway 23 towards the center of the section of the induction passageway 23. The downstream-side side wall portion 67 connects to a downstream-side edge of the bottom wall portion 65. In addition, the downstream-side side wall portion 67 is positioned further downstream than the main flow path 61 in the induction passageway 23 and connects to an edge 27a of a second communication port 27 which communicates with the main flow path 61.

[0040] As is described above, the inlet port 63 is defined by a connecting portion between the upstream- and downstream-side side wall portions of the outer circumferential wall portion 64 which defines the annular flow path 62 and the induction passageway.

[0041] The exhaust gas introduction flow path 80 connects to the annular flow path 62 so that a flow of exhaust gases G is generated in one direction A1 of the circumferential direction A in the annular flow path 62. The one direction A1 is the same direction as a rotating direction of the compressor 71. Fig. 5 shows a state in which the annular flow path 62 is cut or sectioned so as to cross vertically an axis 61 a of the main flow path 61. As is shown in Fig. 5, the exhaust gas introduction flow path 80 connects to the annular flow path 62 along the direction of a tangent to an outer circumferential edge 62a of the annular flow path 62 which is defined by an inner surface of the bottom wall 65. The exhaust gas introduction flow path 80 connects to the annular flow path 62 along a direction B in which exhaust gases G flow when they flow into the annular flow path 62 from the exhaust gas introduction flow path 80 in a position where the exhaust gas introduction flow path 80 does not overlap the main flow path 61.

[0042] In the figure, the direction B is indicated by an arrow in which exhaust gases G flow when they flow into the annular flow path 62 from the exhaust gas introduction flow path 80. In addition, in the figure, when seen in a direction parallel to the direction B, a range which overlaps the main flow path 61 is indicated by a pair of chain double-dashed lines 101, 102, whereas ranges which do not overlap the main flow path 61 are indicated by reference numerals 100, 104. The range 100 constitutes a range lying further rightwards than the chain double-dashed line 101. The range 104 constitutes a range lying further leftwards than the chain double-dashed line 102. In this way, the exhaust gas introduction flow path 80 connects into the range 100.

[0043] By the exhaust gas introduction flow path 80 connecting to the annular flow path 62 in the way described above, exhaust gases G which are introduced into the annular flow path 62 from the exhaust gas introduction flow path 80 flow along the one direction A1 of the circumferential direction A as is indicated by arrows in the figure. The exhaust gas introduction flow path 80 constitutes an example of an exhaust gas introduction flow path of the invention.

[0044] Note that the aforesaid connecting construction of the exhaust gas introduction flow path 80 is an example. A different connecting construction may be adopted between the exhaust gas introduction flow path 80 and the annular flow path 62. In short, the exhaust gas introduction flow path 80 may connect to the annular flow path 62 in any way, provided that exhaust gases which are introduced into the annular flow path 62 from the exhaust gas introduction flow path 80 are allowed to flow along the one direction A1 of the circumferential direction A.

[0045] Next, a width w2 of the inner surface 65a of the bottom wall portion 65 of the annular flow path 62 will be described. Note that when mentioned herein, the width w2 denotes a length along the axis 61 a of the main flow path 61, as is shown in Fig. 3. The inner surface 65a constitutes an example of a bottom edge of the invention. In this embodiment, an axis 23a of the induction passageway 23 overlaps of coincides with the axis 61 a of the main flow path 61. Therefore, the axis 23a is the axis 61 a or vice versa. The width w2 is a width which extends across one direction of a bottom surface which faces an inlet port of the annular flow path of the invention. The width w2 may be a width of an inner face facing the inlet port of the annular flow path 62, in a case where the main flow path 61 and a direction of an axis 23a of the induction passageway 23 are perpendicular to the circumferential direction A of the annular flow path 62.

[0046] Firstly, as is shown in Fig. 5, a first position P1 and a second position P2 are set on the inner surface 65a. In the inner surface 65a, the first position P1 is set in a position which faces a connecting portion 200 where the exhaust gas introduction flow path 80 connects to the annular flow path 62. In the inner surface 65, the second position P2 is set in any position which lies downstream of the first position P1 along the one direction A1 (the direction in which exhaust gases G flow).

[0047] In this embodiment, as an example, the second position P2 constitutes a position which advances 270 degrees downwards about the axis 61 a from the first position P1. In other words, in Fig. 5, an angle becomes 90 degrees which is formed by a first imaginary line v1 which connects the first position P1 and the axis 61 a of the main flow path 61 and a second imaginary line v2 which connects the second position P2 and the axis 61a.

[0048] Fig. 6 schematically shows a flow path section when a flow path defined within the annular flow path 62 is sectioned in a direction which crosses the circumferential direction A. Fig. 6 also shows a width w1 of the flow path section at the inlet port 63 and the width w2 of the inner surface 65a of the bottom wall portion 65. Note that when used herein, the width w1 denotes a length of an opening of the inlet port 63 which follows the axis 61a of the main flow path 61.

[0049] In Fig. 6, as an example, there are shown first and second flow path sections s1, s2 which pass through the first position P1 and the axis 61 a of the main flow path 61 and third and fourth flow path sections s3, s4 which pass through the second position P2 and the axis 61 a of the main flow path 61. The annular flow path 62 shown in Fig. 6 is shown so as to show positions of the first to fourth flow sections s1 to s4 in the annular flow path 62, and hence, sizes of the first to fourth flow path sections s1 to s4 relative to the annular flow path 62 shown therein are not accurate.

[0050] As is shown in Fig. 6, the width w2 of the inner surface 65a of the bottom wall portion 65 is shortened continuously from the first position P1 towards the second position P2. In other words, the inner surface 65a is narrowed continuously from the first position P1 towards the second position P2. In addition, the width w2 of the inner surface 65a of the bottom wall portion 65 is lengthened in a range which extends along the one direction A1 from the second position P2 to the first position P1.

[0051] The width w1 of the inlet port 63 does not change. In other words, the width w1 of the inlet port 63 is constant along the circumferential direction.

[0052] The flow path section (the area of the flow path section) of the annular flow path 62 is set so as to decrease continuously as the annular flow path 62 extends downstream from the first flow path section s1 to the fourth flow path section s4. Assuming that a length which connects the inlet port 63 and the bottom wall portion 65 in each flow path section is referred to as a width w3, the width 3 is shortened continuously as the annular flow path 62 extends along the one direction A1 from the first position P1 to the second position P2.

[0053] Shown within a range F6 in Fig. 6 are schematic diagrams which each show the width w1 of the inlet port 63, the width w2 of the bottom wall portion 65, the width w3 between the inlet port 63 and the bottom wall portion 65 and area of each of the first to fourth flow path sections s1 to s4.

[0054] The contents of the range F6 will be described specifically. In this embodiment, as is shown in the figure, the width w2 of the inner surface 65a of the bottom wall portion 65 (the length of the inner surface 65a along the axis 61 a) is expressed by a relative value to the width w1 based on the width w1 of the inlet port 63 (the length of the inlet port 63 along the axis 61 a). In this embodiment, the width w1 of the inlet port 63 takes a constant value along the circumferential direction of the main flow path 61. The width w1 of the inlet port 63 is referred to as a reference value as being 1.

[0055] The width w2 of the inner surface 65a becomes 1 at the first flow path section s1 in the first position P1. The width w2 of the inner surface 65 becomes 0.8 at the third flow path section s3. The width w2 of the inner surface 65a becomes 0.6 at the second flow path section s2. The width w2 of the inner surface 65a becomes 0.4 at the fourth flow path section s4 in the second position P2.

[0056] The width w3 between the inlet port 63 and the bottom wall portion 65 is not expressed by a relative value to the width w1 of the inlet port 63 but is expressed by a relative value of the width 3 in each position relative to the width w3 in the first position P1 with the width w3 of the first flow path section s1 in the first position P1 referred to as a reference value as being 1.

[0057] The width 3 becomes 1 at the first flow path section s1 in the first position P1. The width w3 becomes 0.7 at the third flow path section s3. The width w3 becomes 0.6 at the second flow path section s2. The width w3 becomes 0.5 at the fourth flow path section s4 in the second position P2.

[0058] Because of this, relative values of the respective flow path sections are as follows. An area of the first flow path section s1 in the first position P1 becomes 1. An area of the third flow path section s3 becomes 0.63. An area of the second flow path section s2 becomes 0.48. An area of the fourth flow path section s4 in the second position P2 becomes 0.35.

[0059] Next, the annular flow path 62 will be described. The annular flow path 62 is defined by respective inner surfaces 65a, 66a, 67a of the bottom wall portion 65, the upstream-side side wall portion 66 and the downstream-side side wall portion 67.

[0060] As is shown in Fig. 3, the inner surface 67a of the downstream-side side wall portion 67 is flat. An angle α defined by the inner surface 67a of the downstream-side side wall portion 67 and an inner surface 25a of the tubular member 25 which defines the induction passageway 23 is 90 degrees along the full circumference of the main flow path 61 in the circumferential direction. The inner surface 67a of the downstream-side side wall portion 67 constitutes an example of a downstream-side edge of the invention. A connecting portion 90 between the inner surface 67a of the downstream-side side wall portion 67 and the inner surface 25a of the tubular member 25 which defines the induction passageway 23 is formed so as to extend moderately from the inner surface 67a to the inner surface 25a. The connecting portion 90 may be round chamfered. The angle α constitutes an angle which is formed by an inner wall surface of the annular flow path which forms a downstream-side opening edge portion of the induction passageway at the inlet port and an inner wall surface of the induction passageway of the invention.

[0061] The inner surface 66a of the upstream-side side wall portion 66 is flat. An angle θ formed by the inner surface 66a of the upstream-side side wall portion 66 and the inner surface 25a of the tubular member 25 which defines the induction passageway 23 is smaller than the angle α along the full circumference of the main flow path 61 in the circumferential direction. In this embodiment, since the angle α is referred to as 90 degrees as an example, the angle θ is an acute angle. The inner surface 66a of the upstream-side side wall portion 66 constitutes an example of an upstream-side edge of the invention. The angle θ constitutes an example of an angle formed by the inner wall surface of the annular flow path which forms the upstream-side opening edge portion of the induction passageway at the inlet port and the inner wall surface of the induction passageway of the invention.

[0062] A connecting portion between the inner surface 66a of the upstream-side side wall portion 66 and the inner surface 25a of the tubular member 25 which defines the induction passageway 23 is formed so as to extend moderately from the inner surface 25a to the inner surface 66a. In addition, as is shown in Fig. 3, a projecting portion 400 which projects towards the induction passageway 23 side is formed at the connecting portion between the inner surface 25a of the induction passageway 23 and the inner surface 66a so that the angle θ becomes smaller than the angle α. To be more specifically, since the constriction portion 110, which will be described later, is formed in the induction passageway 23, the connecting portion between the inner surface 25a of the induction passageway 23 and the inner surface 66a is made into the projecting portion 400 which projects towards the axis 23a side of the induction passageway 23. A distal end of the projecting portion 400 constitutes the edge 26a. A portion of the projecting portion 400 constitutes the inner surface 66a and the other portion thereof constitutes the inner surface 25a. The projecting portion 400 is set so that the angle θ defined by the portion of the projecting portion 400 which constitutes the inner surface 66a and the portion of the projecting portion 400 which constitutes the inner surface 25a is smaller than the angle α.

[0063] Looking at the inner surface 65a of the bottom wall portion 65 in a section which crosses the circumferential direction A as is shown in Fig. 3, the inner surface 65a is straight-line. An angle β formed by the inner surface 65a of the bottom wall portion 65 and the inner surface 67a of the downstream-side side wall portion 67 is 90 degrees along the full circumference of the main flow path 61 in the circumferential direction. A connecting portion 91 between the inner surface 65a and the inner surface 67a is formed so as to extend moderately from the inner surface 65a to the inner surface 67a. The connecting portion 91 may be round chamfered.

[0064] Looking at the annular flow path 62 which is sectioned in a direction which crosses the circumferential direction A, the inner surface 66a of the upstream-side side wall portion 66 is straight-line. The inner surface 66a of the upstream-side side wall portion 66 is inclined relative to the inner surface 65a of the bottom wall portion 65, and an angle γ defined by the inner surface 65a and the inner surface 66a is an obtuse angle (90 degreessy≤γ<180 degrees). The inner surface 66a constitutes an example of an upstream-side edge of the invention. The inner surface 65a and the inner surface 66a connect moderately to each other.

[0065] As has been described above, the width w2 of the inner surface 65a is shortened continuously along the one direction A1 from the first position P1 to the second position P2. Specifically, the width w2 changes as the inclination (the angle γ) of the inner surface 66a of the upstream-side side wall portion 66 relative to the inner surface 65a of the bottom portion 65 changes. A connecting portion 92 between the inner surface 66a of the upstream-side side wall portion 66 and the inner surface 25a of the induction passageway 23 is formed so as to extend moderately from the inner surface 66a to the inner surface 25a. The connecting portion 92 may be round chamfered.

[0066] As this occurs, the inner surface 65a of the bottom wall portion 65 and the inner surface 67a of the downstream-side side wall portion 67 do not change. Namely, the angle α defined by the inner surface 65a and the inner surface 67a is maintained at 90 degrees.

[0067] Net, the construction of a position in the induction passageway 23 which lies further upstream than the main flow path 61 will be described. The position in the induction passageway 23 which lies just upstream of the main flow path 61 is configured as the constriction portion 110. The constriction portion 110 is constricted so that the flow path section decreases relative to the portion lying further upstream than the constriction portion 110. In this embodiment, the constriction portion 110 is positioned downstream of the throttle valve 24.

[0068] Next, the operation of the low-pressure EGR system 50 will be described. When circumstances require exhaust gases to be supplied by use of the low-pressure EGR system 50 in accordance with an operating condition of the diesel engine 11, the low-pressure EGR valve 300 opens. When low-pressure EGR gases are ready to be supplied, that is, the low-pressure EGR valve 300 opens, a portion of EGR gases G flows into the exhaust gas introduction flow path 80 from the exhaust passageway 31. As is shown in Fig. 5, the exhaust gases G which flow into the exhaust gas introduction flow path 80 then flow into the annular flow path 62 from the exhaust gas introduction flow path 80.

[0069] The exhaust gases G which flow into the annular flow path 62 then flow downstream from the first position P1 along the one direction A1. As this occurs, as is shown in the figure, the exhaust gases G flow mainly along the inner surface 65a of the bottom wall portion 65 by virtue of a centrifugal force due to the bottom wall portion 65 which is curved in an annular fashion. The portion of EGR gases flows into the main flow path 61 from the inlet port 63.

[0070] The momentum of the flow of exhaust gases G within the annular flow path 62 becomes the strongest at the connecting portion 200 between the exhaust gas introduction flow path 80 and the annular flow path 62 and then decreases as the exhaust gases G flow downstream along the one direction A1. In addition, the amount of exhaust gases G becomes the largest at the connecting portion 200 and decreases as the exhaust gases G flow downstream along the one direction A1.

[0071] Because of this, the momentum of the flow of exhaust gases G is strong in a position in the inlet port 63 which lies in the vicinity of the first position P1, and also, the amount of exhaust gases G that flow into the inlet port 63 in that position becomes large. In contrast, the momentum of the flow of exhaust gases G is weak in a position in the inlet port 63 which lies in the vicinity of the second position P2 which lies downstream of the first position P1, and the amount of exhaust gases that flow into the inlet port 63 in that position becomes small.

[0072] The width w2 of the inner surface 65a is set so as to decrease as the momentum of the flow of exhaust gases G weakens and the amount of exhaust gases decreases so that the amount of exhaust gases G that flow into the main flow path 61 from every position in the inlet port 63 becomes even.

[0073] In other words, since the momentum of the flow of exhaust gases G is strong and the amount thereof is large in the position in the inlet port 63 which lies near the first position P1 which faces the connecting portion 200 between the exhaust gas introduction flow path 80 and the annular flow path 62, it is ensured that a sufficient amount of exhaust gases G flows into the main flow path 61. Because of this, the width w2 of the inner surface 65a is made relatively large.

[0074] By making the width w2 of the inner surface 65a shorten as the bottom wall portion 65 extends from the first position P1 to the second position P2, the exhaust gases G which flow along the inner surface 65a are pushed towards a center side of the annular flow path 62 or towards the inlet port 63 side. According to this configuration, even in the event that the amount of exhaust gases G decreases and the momentum of the flow of exhaust gases G weakens as the exhaust gases G flow towards the second position P2, the exhaust gases G which are pushed towards the inlet port 63 side flow into the main flow path 61. Therefore, it is ensured that a sufficient amount of exhaust gases G flow into the main flow path 61 even in the downstream positions. As a result of this, the amount of exhaust gases G which flow into the main flow path 61 becomes even in every position in the inlet port 63. In addition, since the flow path section (the area of the flow path section) of the annular flow path 62 is set so as to decrease continuously from the first flow path section s1 to the fourth flow path section s4 as the annular flow path 62 extends downstream, the exhaust gases G within the annular flow path 62 are pushed towards the main flow path as they flow downstream. Further, since the width 3, which is the length between the inlet port 63 and the bottom wall portion 65, is set so as to shorten continuously from the first position P1 to the second position P2 as the annular flow path 62 extends along the one direction A1, the exhaust gases G in the annular flow path 62 is guided to flow towards the main flow path as they flow downstream. According to this configuration, the exhaust gases G are made easy to flow into the main flow path 61 even at the downstream side of the annular flow path 62, and the amount of exhaust gases G which flows into the main flow path 61 becomes even in every position in the inlet port 63.

[0075] Fresh air N which has passed through the air cleaner 21 mixes evenly with exhaust gases G in the main flow path 61. Because of this, the flow velocity distribution of a mixture M of fresh air N and exhaust gases G in a flow path section which extends vertically across the axis 23a of the induction passageway 23 becomes substantially uniform even directly below the main flow path 61 in a region in the induction passageway 23 which lies further downstream than the main flow path 61.

[0076] Pressure applied to the compressor 71 becomes even in every position due to the flow velocity distribution becoming substantially even in the position in the induction passageway 23 which lies just downstream of the main flow path 61.

[0077] Fig. 7 is a side view of a portion of the induction passageway 23 which lies in the vicinity of the throttle valve 24 as seen from a side thereof. In the figure, the tubular member 25 which configures the induction passageway 23 is cut away in the position lying in the vicinity of the throttle valve 24.

[0078] As is shown in Fig. 7, in the induction passageway 23, there is a tendency to form a dead water region 120 where the flow of fresh air N is stagnant on the periphery of the throttle valve 24. A range indicated by a chained line in the figure denotes the dead water region 120. However, the constriction portion 110 is provided, whereby since there is generated a current vector which is directed towards the axial center of the induction passageway 23, the dead water region 120 is moved to the downstream side. As a result, the dead water region 120 is set further upstream of the main flow path 61. In other words, the constriction portion 110 is formed so that the dead water region 120 is not formed in the main flow path 61 or further downstream of the main flow path 61. In addition, fresh air N which flows into the main flow path 61 from the induction passageway 23 is guided in the direction of the axial center of the main flow path 61 by the existence of the constriction portion 110, whereby fresh air can be prevented from flowing into the annular flow path 62.

[0079] The connecting portion 90 between the inner surface 67a of the downstream-side side wall portion 67 of the annular flow path 62 and the inner surface 25a which defines the induction passageway 23 is formed moderately. The angle α at the connecting portion 90 is made larger than the angle θ at the connecting portion between the inner surface 66a and the inner surface 25a which is formed by the inner surface 66a of the upstream-side side wall portion 66 and the inner surface 25a which defines the induction passageway 23. This prevents exhaust gases G from being separated from the inner surface 25a when exhaust gases G flow into the main flow path 61 from the annular flow path 62. The flow velocity of exhaust gases G in the vicinity of the inner surface 25a is decreased by the separation of exhaust gases G from the inner surface 25a. Namely, the flow velocity distribution of the mixture M becomes even in the region in the induction passageway 23 which lies further downstream than the main flow path 61 by suppressing the separation of exhaust gases G from the inner surface 25a.

[0080] In this way, in this embodiment, the width w2 of the inner surface 65a is made to decrease continuously as the annular flow path 62 extends downstream along the one direction A1, whereby the amount of exhaust gases G which flow into the main flow path 61 from the inlet port 63 becomes even in every position in the inlet port 63. Because of this, the flow velocity distribution of the mixture M becomes even in the region in the induction passageway 23 which lies further downstream than the main flow path 61.

[0081] As a result, even in a construction like the embodiment in which the compressor 71 is disposed just downstream of the main flow path 61, the generation of drawbacks attributed to the flow velocity of the mixture M becoming uneven is prevented. The drawbacks include a contact of the compressor 71 with a housing 71 a which accommodates the compressor 71 and wear generated between a rotating shaft 73 of the compressor 71 and a bearing 72 which supports the rotating shaft 73.

[0082] Since resistance produced when exhaust gases G flow into the induction passageway 23 is decreased by forming the inlet port 63 into the annular shape which continues along the circumferential direction, exhaust gases G are allowed to be introduced into the induction passageway 23 with good efficiency.

[0083] The change in the width w2 of the inner surface 65a is controlled or adjusted by changing the inclination of the inner surface 66a of the upstream-side side wall portion 66 relative to the inner surface 65a of the bottom wall portion 65. By doing so, the angle α defined by the inner surface 67a of the downstream-side side wall portion 67 and the inner surface 25a of the tubular member 25 which defines the induction passageway 23 can be maintained at 90 degrees.

[0084] The smaller the angle α defined by the inner surface 67a of the downstream-side side wall portion 67 and the inner surface 25a of the tubular member 25 becomes, the easier exhaust gases G are made to be separated from the inner surface 25a.

[0085] In this embodiment, while the angle α defined by the inner surface 67a and the inner surface 25a is 90 degrees, the invention is not limited thereto. In the event that the angle α formed by the inner surface 67a and the inner surface 25a takes any angular value between 90 degrees or more to less than 180 degrees, the inner surface 67a is allowed to connect to the inner surface 25a moderately, thereby making it possible to suppress the separation of exhaust gases G from the inner surface 25a.

[0086] A range F3 in Fig. 3 shows other examples of angles α (angles other than 90 degrees) which are defined by the inner surface 25a and the inner surface 67a. The examples include one example in which the angle α is 120 degrees and the other example in the angle α is 150 degrees. In these cases, too, the connecting portion 90 between the inner surface 25a and the inner surface 67a is formed moderately. In these cases, too, a similar function and advantage to those of the subject patent application can be obtained.

[0087] In this embodiment, the connecting portion 60 is formed through casting. Because of this, the change in width of the inner surface 65a of the bottom wall portion 65 is effected by changing the configuration of a mold used. It is relatively easy to control the configuration of the mold to control the width of the inner surface 65a of the bottom wall portion 65. Because of this, an increase in costs incurred for molds involved can be suppressed.

[0088] Next, an exhaust gas recirculation system according to a second embodiment of the invention will be described by use of Figs. 8, 9. Note that like reference numerals will be given to like configurations or constituent elements to those of the first embodiment, and the description thereof will be omitted here. This embodiment differs from the first embodiment in that a width w1 of an inlet port 63 differs. The other constructions may be similar to those of the first embodiment. The aforesaid different construction will be described below.

[0089] Fig. 8 is a sectional view of a connecting portion 60 and portions lying in the vicinity of the connecting portion 60 which are sectioned along a plane passing through an axis 61a of a main flow path 61 and a first position P1 and are viewed obliquely from thereabove. Fig. 9 is a schematic diagram showing schematically first to fourth flow path sections s1 to s4 of an annular flow path 62.

[0090] As is shown in Figs. 8, 9, in this embodiment, the width w1 of the inlet port 63 also changes in addition to features like those described in the first embodiment that a width w2 of an inner surface 65a of a bottom wall portion 65 changes from the first position P1 to a second position P2 and that an area of a flow path section of the annular flow path 62 which crosses one direction A1 decreases continuously as the annular flow path 62 extends downstream. Specifically, the width w1 of the inlet port 63 lengthens as the annular flow path 62 extends downstream.

[0091] A range F9 shown in Fig. 9 shows the width w1 of the inlet port 63, the width w2 of the inner surface 65a of the bottom wall portion 65, a width w3 between the inlet port 63 and the inner surface 65a and an area of each of the first to fourth flow path sections s1 to s4.

[0092] As is shown in the range F9 in Fig. 9, the width w2 of the inner surface 65a of the bottom wall portion 65 and the width w1 of the inlet port 63 are expressed based on the width w2 of the inner surface 65a of the first section s1 which passes through the first position P1 as a reference length as being 1 and are actually expressed by relative values to the reference length. As is shown in the range F9, in the first flow path section s1 in the first position P1, the width w2 of the inner surface 65a of the bottom wall portion 65 is 1, and the width w1 of the inlet port 63 is 0.4. In the third flow path section s3, the width w2 of the inner surface 65a of the bottom wall portion 65 is 0.8, and the width w1 of the inlet port 63 is 0.6. In the second flow path section s2, the width w2 of the inner surface 65a of the bottom wall portion 65 is 0.6, and the width w1 of the inlet port 63 is 0.8. In the fourth flow path section s4 in the second position P2, the width w2 of the inner surface 65a of the bottom wall portion 65 is 0.4, and the width w1 of the inlet port 63 is 1.

[0093] In the range F9, the width w3 between the inlet port 63 and the inner surface 65a of the bottom wall portion 65 is not expressed as a relative value to the width w2 of the inner surface 65a of the bottom wall portion 65 but is expressed by a relative value of the width w3 in each flow path section to a reference length as being 1 which is the width w3 between the inlet port 63 and the inner surface 65a of the bottom wall portion 65 in the first flow path section s1 in the first position P1. As is shown in the range F9, in the first flow path section s1 in the first position P1, the width w3 is 1. In the third flow path section s3, the width w3 is 0.7. In the second flow path section s2, the width w3 is 0.6. In the fourth flow path section s4 in the second position P2, the width w3 is 0.5.

[0094] In the range F9, respective relative values of the areas of the flow path sections s1 to s4 are shown. The area of the first flow path section s1 in the first position P1 is 0.7. The third flow path section s3 is 0.49. The area of the second flow path section s2 is 0.42. The area of the fourth flow path section s4 in the second position P2 is 0.35.

[0095] Next, the feature that the width w1 of the inlet port 63 lengthens will be described below. As is shown in Fig. 8, in this embodiment, too, an angle α which is defined by an inner surface 67a of a downstream-side side wall portion 67 and an inner surface 25a of a tubular member 25 which defines an induction passageway 23 is 90 degrees. In addition, an angle β which is defined by the inner surface 65a of the bottom wall portion 65 and the inner surface 67a of the downstream-side side wall portion 67 is also 90 degrees. Because of this, an end portion 65b of the bottom wall portion 65 which faces the upstream-side side wall portion 66 is shortened as the bottom wall portion 65 extends downstream.

[0096] In this embodiment, the width w1 of the inlet port 63 lengthens continuously along one direction A1, whereby in addition to the advantage provided by the first embodiment, exhaust gases G are made easy to flow into the main flow path 61 at a downstream side of the annular flow path 62, as well. A relative relationship between the widths w1 and w2 is set so that the amount of exhaust gases G which flow from the inlet port 63 becomes even in every position in the inlet port 63.

[0097] As the width w2 of the bottom wall portion 65 decreases, the angle α which is defined by the inner surface 67a of the downstream-side side wall portion 67 and the inner surface 25a of the tubular member 25 which defines the induction passageway 23 is maintained constant. In this embodiment, as an example, the angle α is 90 degrees, which is similar to that of the first embodiment. However, the angle α may take any angle which is 90 degrees or more and less than 180 degrees. Because of this, the separation of exhaust gases G from the inner surface 25a of the tubular member 25 is suppressed.

[0098] In this embodiment, too, an angle θ is set so as to be smaller than the angle α.

[0099] Next, an exhaust gas recirculation system according to a third embodiment of the invention will be described by use of Fig. 10. Note that like reference numerals will be given to like configurations or constituent elements to those of the first embodiment, and the description thereof will be omitted here. In this embodiment, in order that an angle α becomes larger than an angle θ, the angle α is set so as to be larger than the angle α by use of a different construction from those described in the first and second embodiments. In this embodiment, a relationship between widths w1, w2, w3 in a flow pass section of a flow path which is defined within an annular flow path 62 and the flow path section differs from that of the first embodiment. The other constructions may be similar to those of the first embodiment.

[0100] In this embodiment, the angle θ is configured so as to be smaller than the angle α without forming a projecting portion 400. Specifically, an inner surface 65a of a bottom wall portion 65 and an inner surface 66a of an upstream-side side wall portion 66 are set so as to be in a straight line when sectioned as is shown in Fig. 10. As this occurs, the angle of the inner surface 66a relative to the inner surface 65a is controlled so that the angle θ defined by the inner surface 66a and an inner surface 25a of an induction passageway 23 becomes smaller than the angle α. More specifically, a width w1 of an inlet port 63 is set so as to be smaller than a width w2 of the inner surface 65a of the bottom wall portion 65 at all times. Then, the widths w1, w2 take constant values along a circumferential direction A. Note that the angle α is the same as that of the first embodiment.

[0101] By adopting this configuration, the angle θ becomes smaller than the angle α in any position along the circumferential direction A.

[0102] In this embodiment, since the widths w1, w2 are set in the way described above, the relative relationship between the widths w1, w2, w3 and the areas of the flow path sections s1 to s4 is not set in the way shown in Fig. 6 of the first embodiment.

[0103] In the embodiment, the example of the construction is described in which the angle α is larger than the angle θ, and the relationship between the widths w1, w2, w3 of the flow path section of the annular flow path 62 and the area of the flow path section may be set in the way described in the first and second embodiments, for example. As this occurs, the same advantage as those of the first and second embodiments can be obtained.

[0104] In the first to third embodiments, the exhaust gas recirculation system is used as the low-pressure EGR system 50. However, the application of the exhaust gas recirculation system of the invention is not limited to the low-pressure EGR system 50.

[0105] In the first to third embodiments, the inlet port 63 is described as being the elongated hole which opens continuously along the circumferential direction A in the annular fashion. However, a plurality of inlet ports 63 may be provided. As this occurs, the diameter of an inlet port in the first position P1 is made small, and the diameters of the inlet ports so provided are made to increase. In contrast, the diameters of the inlet ports are made constant or equal. As this occurs, the number of inlet ports in the first position P1 is made small, and the numbers of inlet ports are made to increase as the annular flow path 62 extends towards the second position P2.

[0106] The invention is not limited to the embodiments described above without any modifications or alterations. In stages in which the invention is specifically carried out, the constituent elements can be specified variously without departing from the spirit and scope of the invention. In addition, various inventions can be formed by combining the plurality of constituent elements disclosed in the above embodiments as require. For example, some constituent elements may be deleted from the whole of the constituent elements described in the above embodiments. Further, the constituent elements of the different embodiments may be combined as required.

Claims

1. An exhaust gas recirculation system **characterized in** comprising:

    an induction passageway through which fresh air flows;
    an annular flow path extending in a circumferential direction of the induction passageway and formed in an annular shape, the annular flow path encompassing the induction passageway therein;
    an inlet port formed between the induction passageway and the annular flow path and communicating the induction passageway with the annular flow path; and
    an exhaust gas introduction flow path commu-

nicated with the annular flow path and configured to introduce the exhaust gases into the annular flow path so that the exhaust gases flow in one direction of the circumferential direction, wherein
the annular flow path has an inner face facing the inlet port, the inner face has a width in a direction crossing the one direction, and
an upstream side of the width is shorter than a downstream side of the width with respect to a flow of the exhaust gasses which flows into the annular flow path from the exhaust gas introduction flow path.

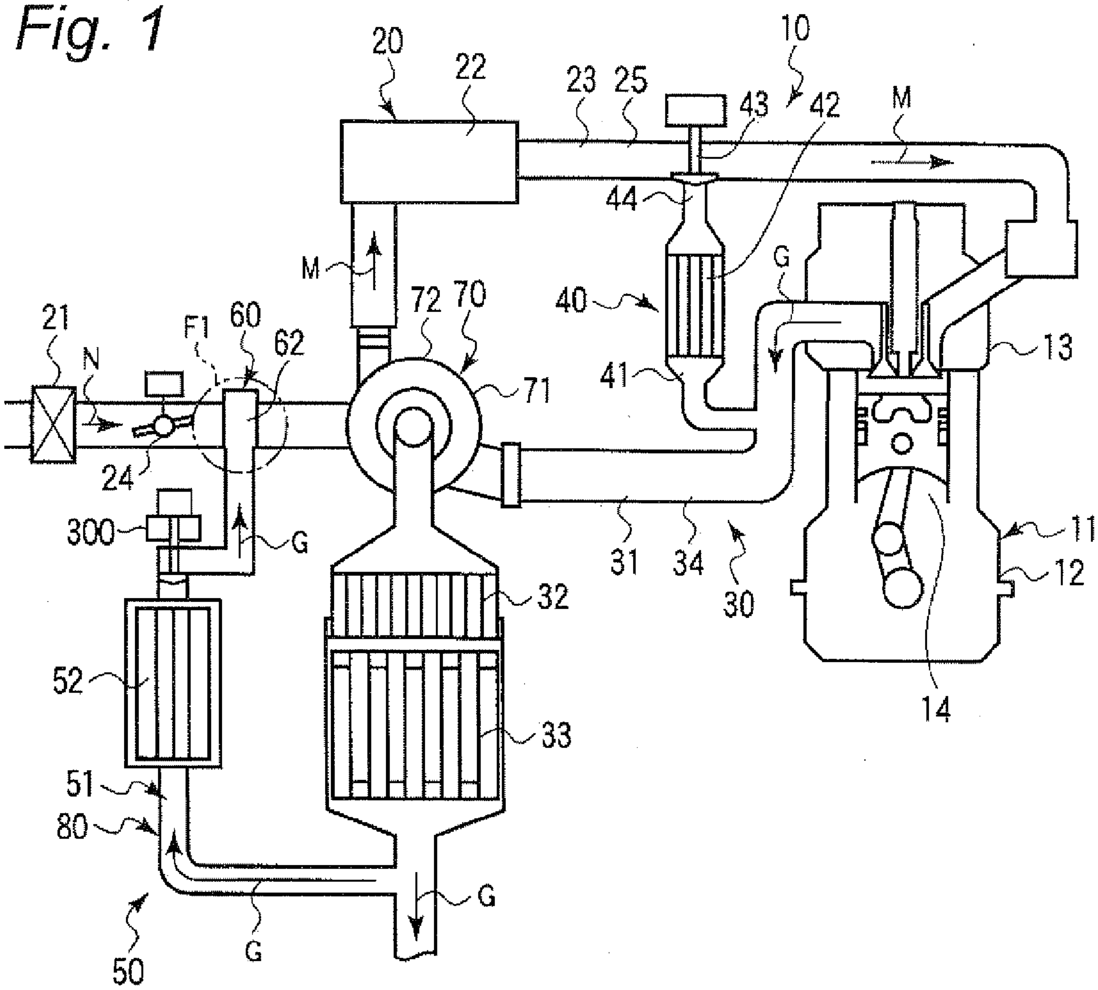
2. The exhaust gas recirculation system according to Claim 1, wherein
a first inner wall surface of the annular flow path which defines an upstream side opening edge of the inlet port at an upstream side of the introduction passageway intersects with an inner wall surface of the introduction passageway at a first angle,
a second inner wall surface of the annular flow path which defines a downstream side opening edge of the inlet port at a downstream side of the introduction passageway intersects the inner wall surface of the introduction passageway at a second angle, and
the second angle is larger than the first angle.

3. The exhaust gas recirculation system according to Claims 1 or 2, wherein
a constriction portion which decreases a flow path sectional area of the induction passageway is formed at the upstream side opening edge of the inlet port at an upstream side of the introduction passageway.

4. The exhaust gas recirculation system according to any one of Claims 1 to 3, wherein
a width of the inlet port in the direction crossing the one direction of the annular flow path becomes longer as the inlet port extends downstream along the one direction.

5. The exhaust gas recirculation system according to any one of Claims 1 to 4, wherein
a flow path section of the annular flow path crossing the one direction of the annular flow path is made smaller as the annular flow path extends downstream along the one direction.

Fig. 1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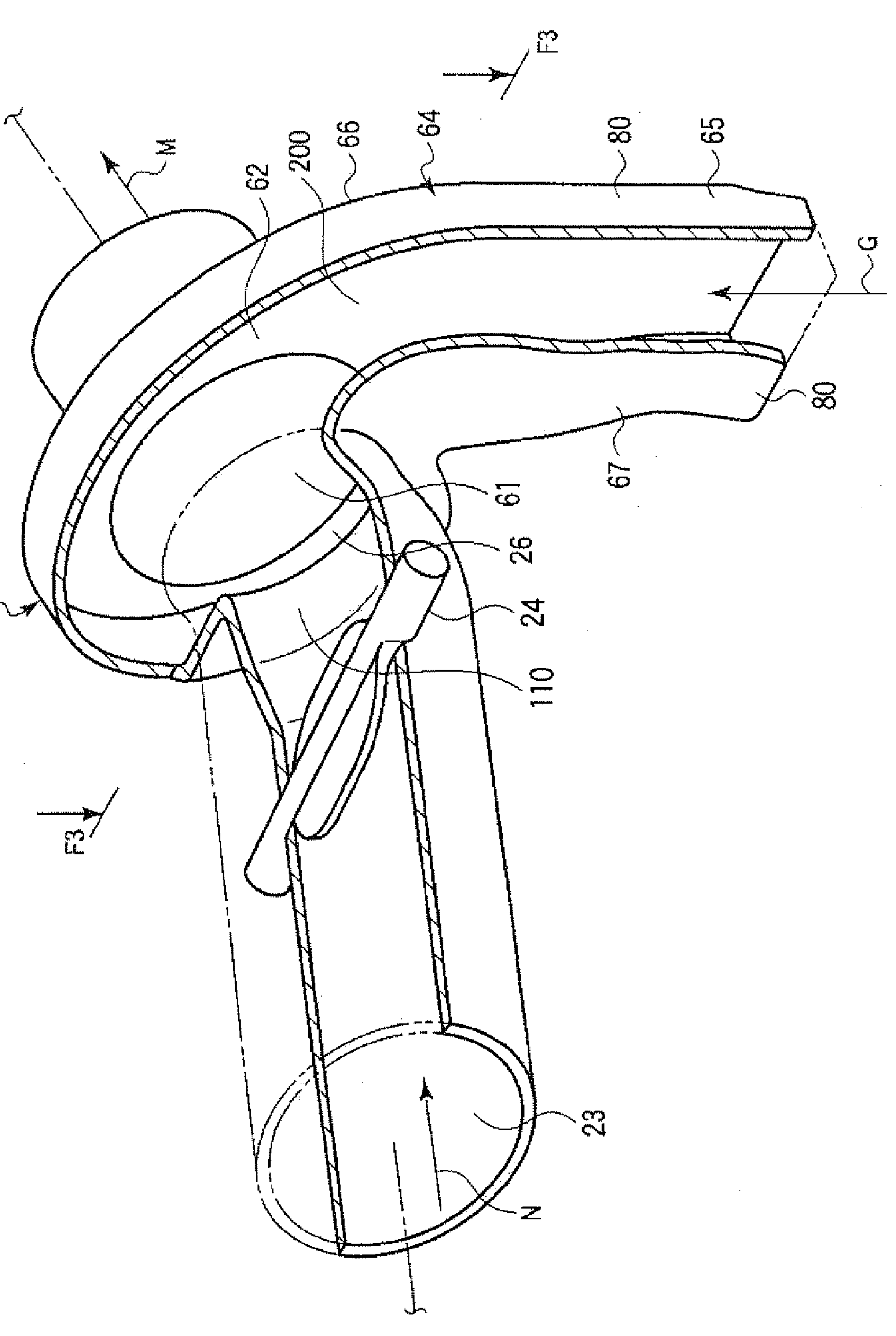

Fig. 2

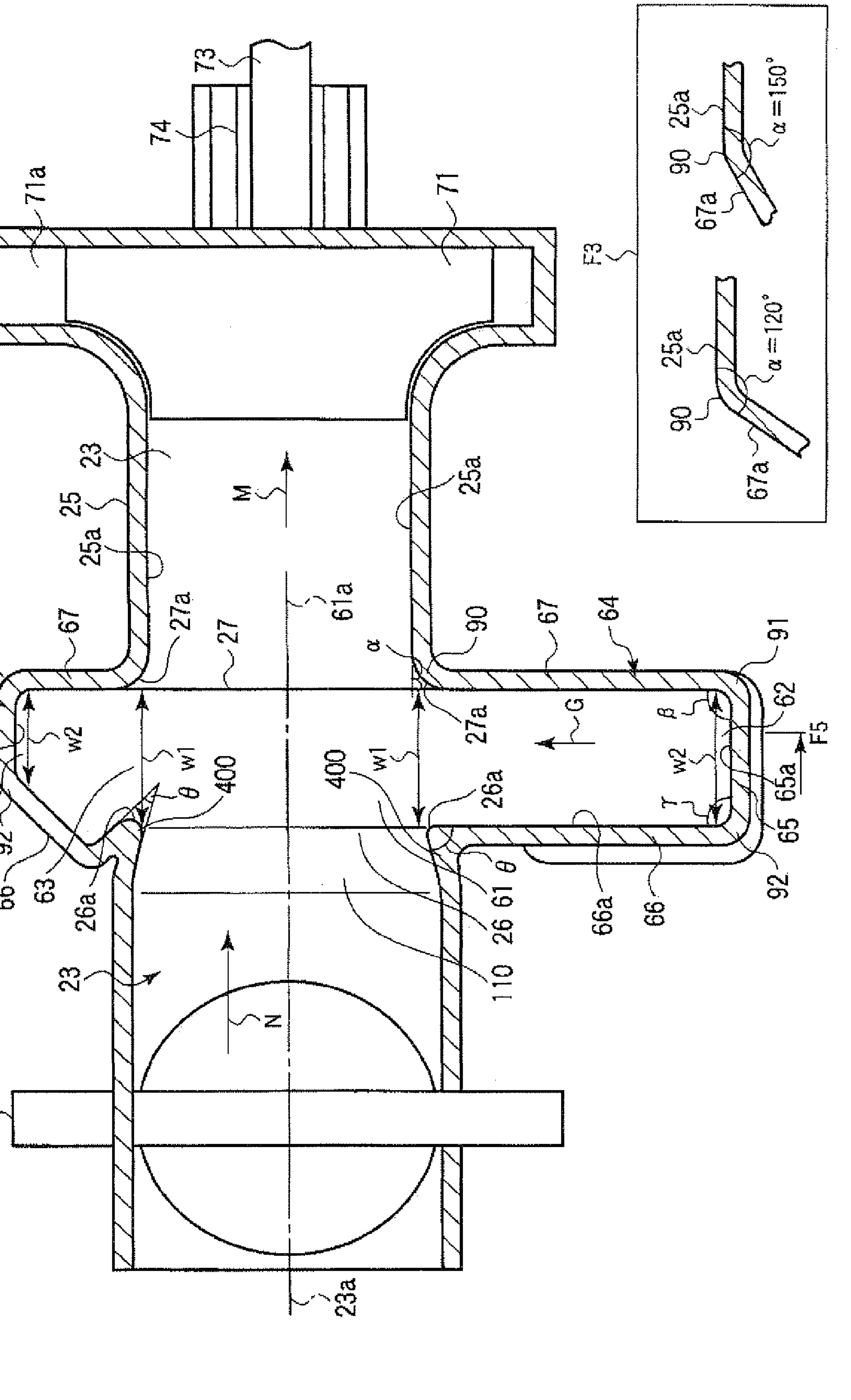
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Fig. 3

Fig. 4

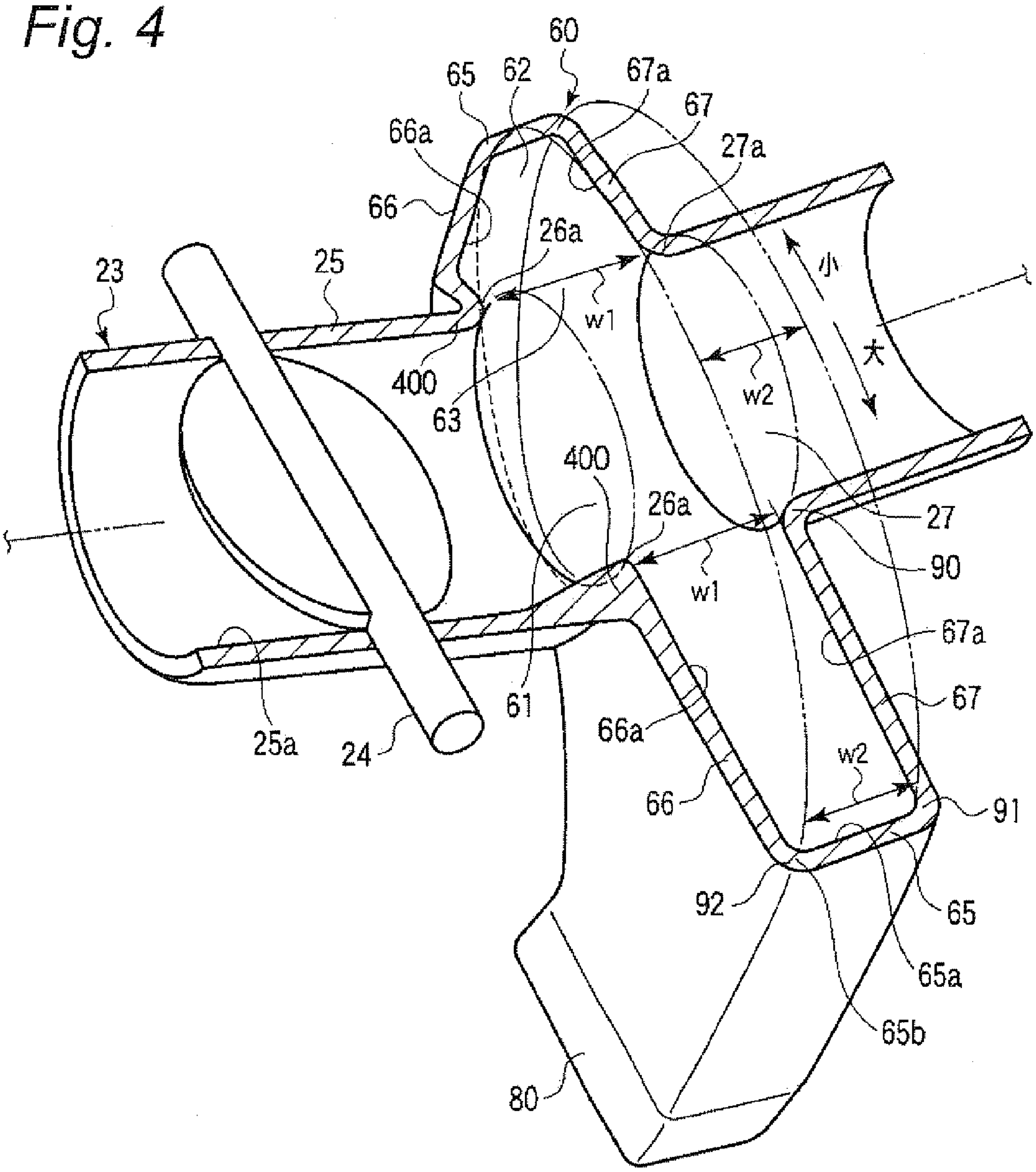
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Fig. 5

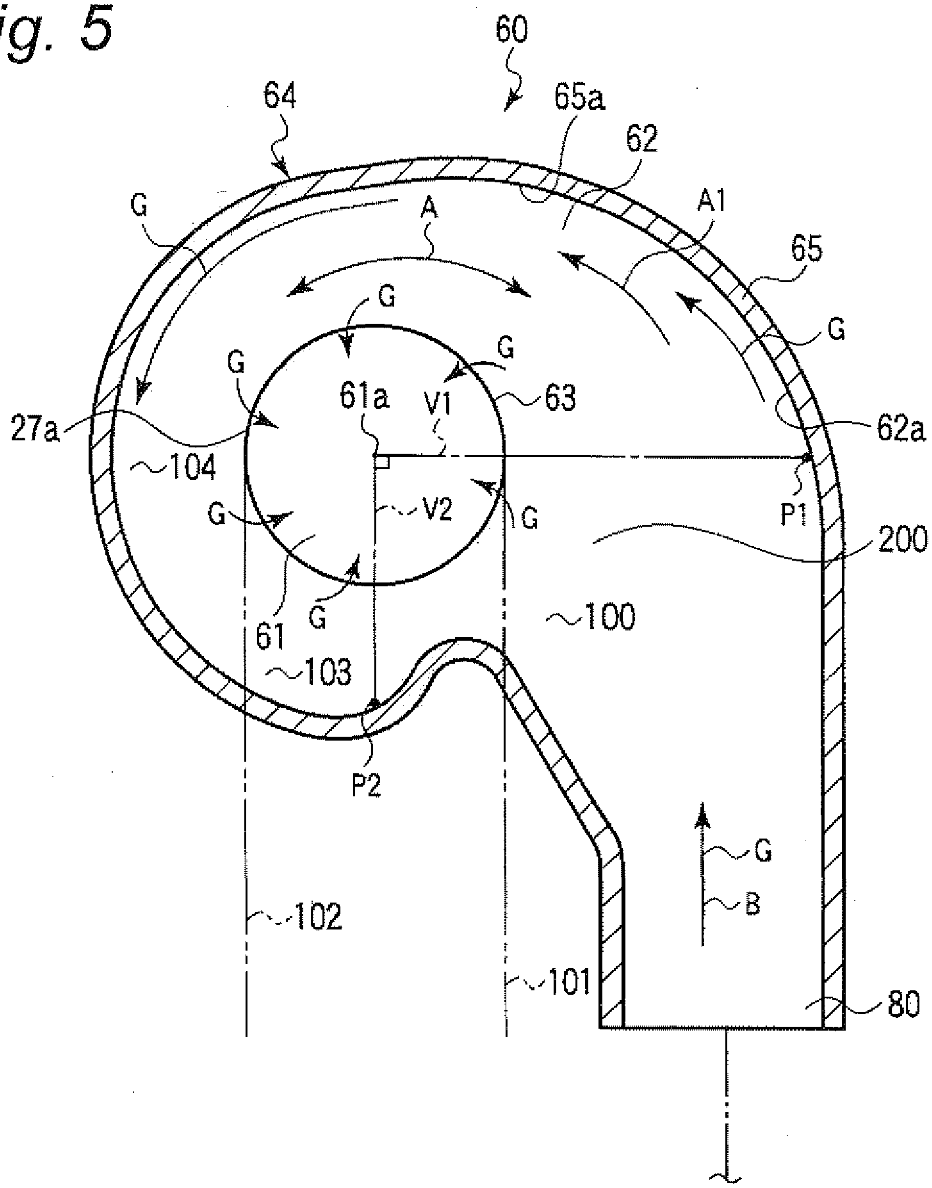
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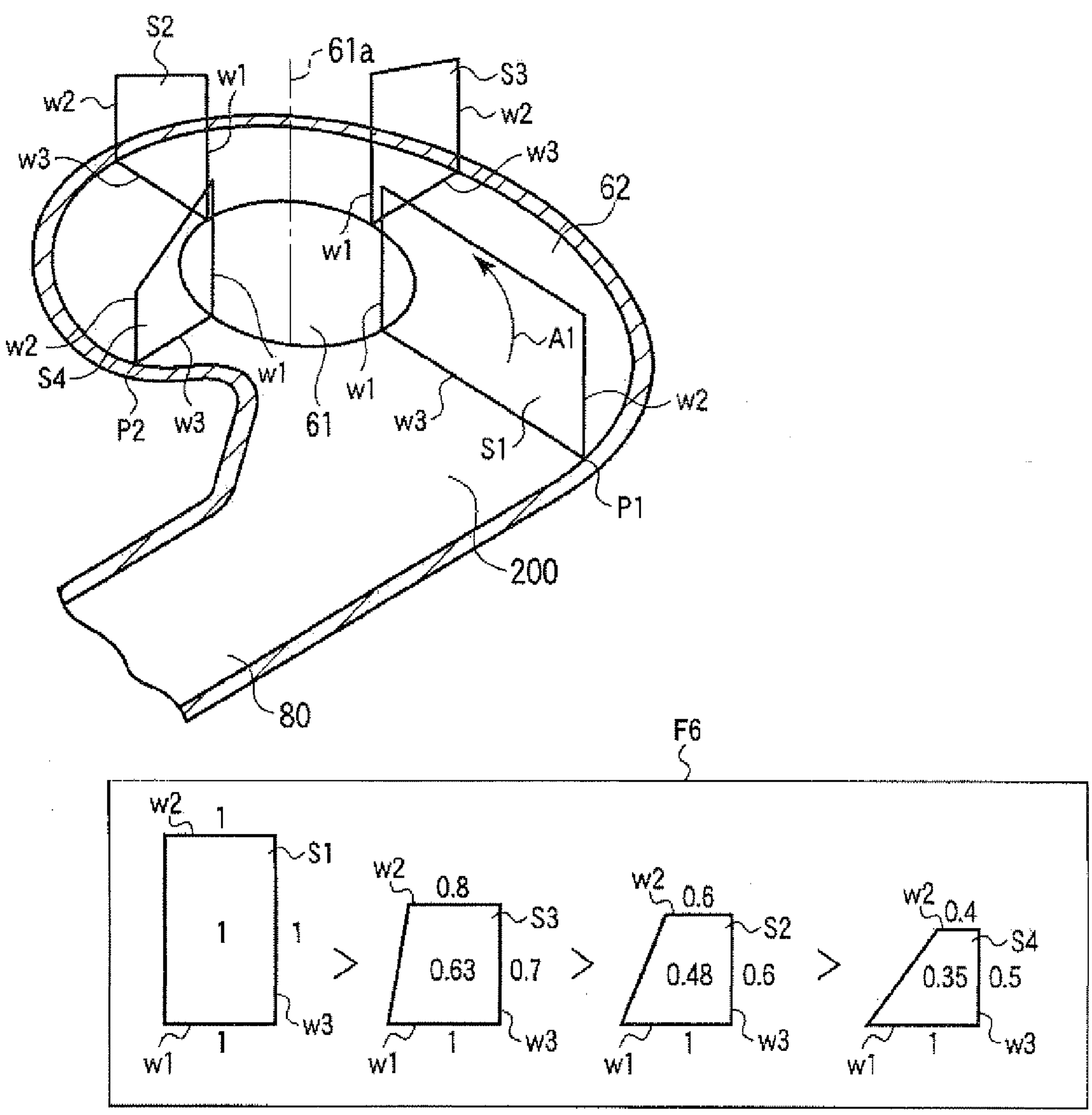
Fig. 6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w3
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Fig. 7

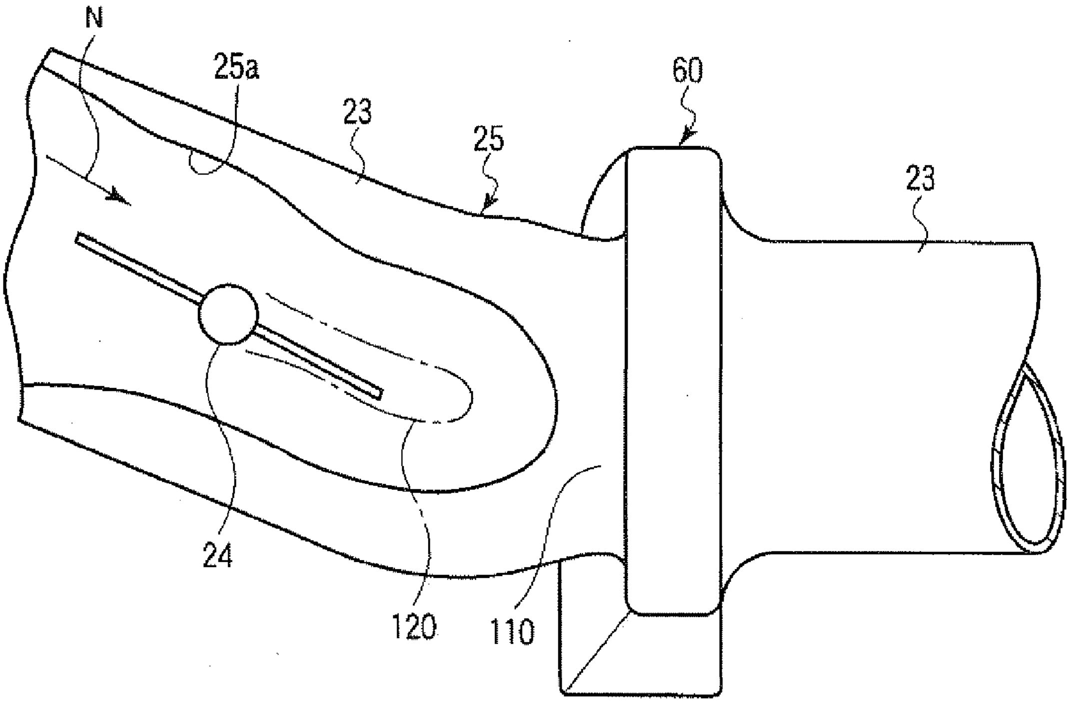
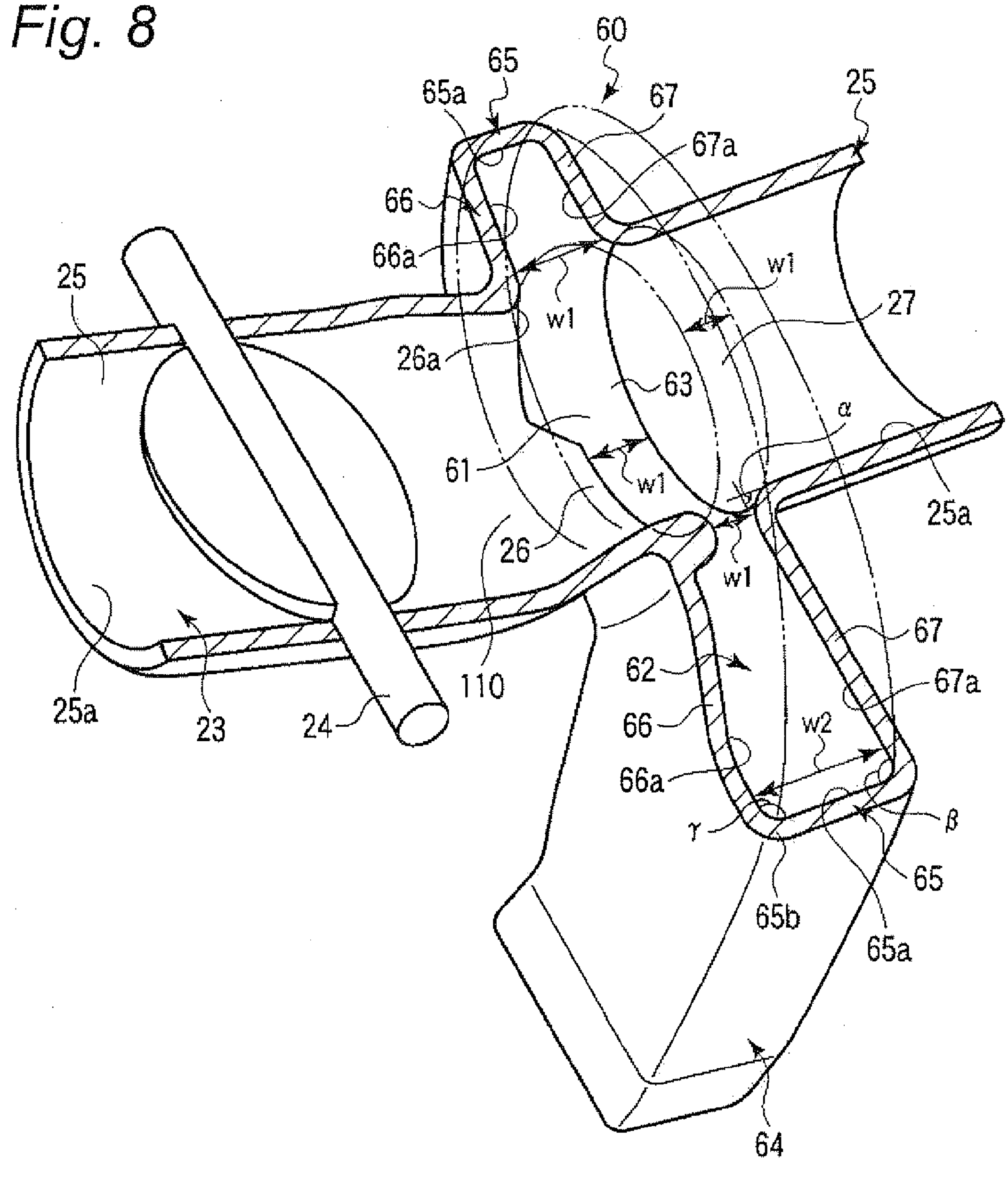


Fig. 8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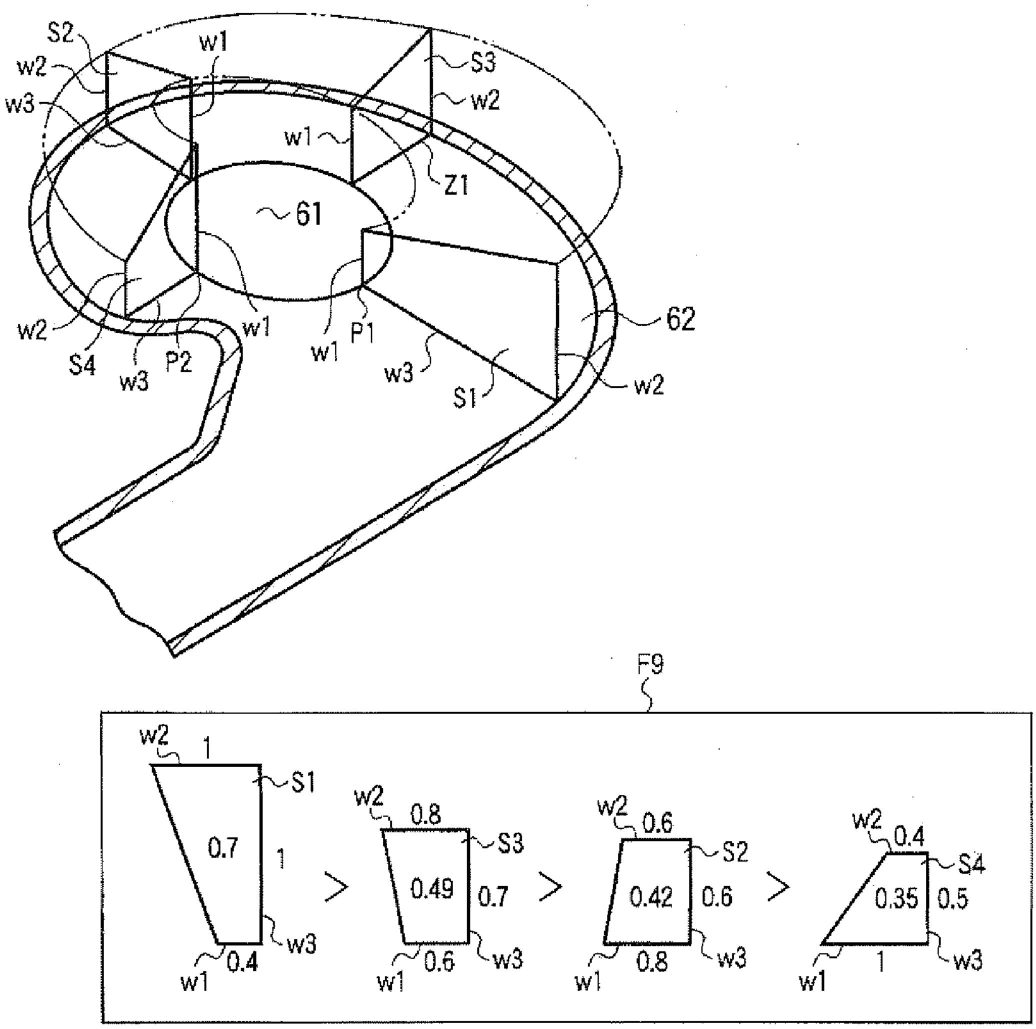
66a
γ
β
65
65b
65a
64

Fig. 9


S2
w2
w3
w1
S3
w2
w1
Z1
61
62
w2
S4
w3
P2
w1
w1
P1
w3
S1
w2
F9
w2
1
S1
0.7
1
w3
w1
0.4
w2
0.8
S3
0.49
0.7
w1
0.6
w3
w2
0.6
S2
0.42
0.6
w1
0.8
w3
w2
0.4
S4
0.35
0.5
w1
1
w3

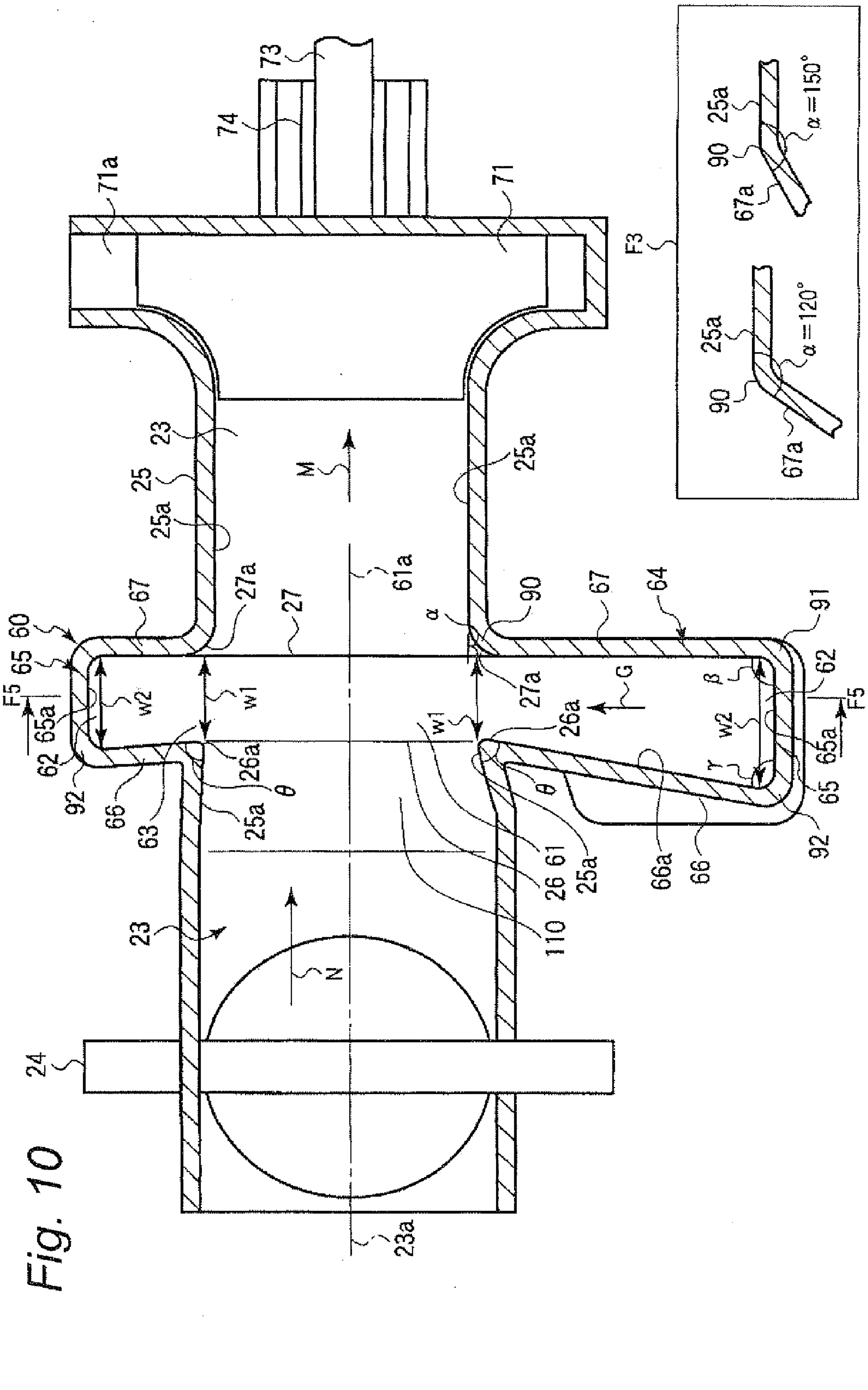


Fig. 10

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3114564 A **[0009]**
- JP 2000161147 A **[0009]**