# ABSTRACT OF THE DISCLOSURE

An intake system is provided that can avoid operational malfunction occurring from oil, etc. permeating inside the EGR pipe and adhering to the EGR valve. In an intake system (2) of an engine (1) disposed to be sloped relative to a horizontal plane upon mounting to a vehicle, the system (2) includes: an intake pipe (3) and an EGR pipe (4) that merges with the intake pipe (3) from below, in which, among both side faces (31, 32) of the intake pipe (3), a side face (31) positioned below includes a groove (35) that extends to a downstream side, by beginning at a first junction (34a) between the side face (31) and a merging part (33) at which the EGR pipe (4) merges with the intake pipe (3) prior to merging, or by passing from a side further upstream than the first junction (34a) through the first junction (34a).

Fig. 4

What is claimed is:

1. An intake system (2) of an internal combustion engine (1) disposed to be sloped relative to a horizontal plane upon mounting to a vehicle, the system (2) comprising:

an intake path (3) that supplies fresh air to a combustion chamber of the internal combustion engine (1); and

an EGR path (4) that merges with the intake path (3) from below, and recirculates a portion of exhaust gas from an exhaust path of the internal combustion engine (1) to the intake path (3) as EGR gas,

wherein, among both side faces (31,32) of the intake path (3), a side face (31) positioned below includes a groove (35) that extends to a downstream side, by beginning at a junction (34a) between the side face (31) and a merging part (33) at which the EGR path (4) merges with the intake path (3) prior to merging, or by passing from a side further upstream than the junction through the junction (34a).

2. The intake system (2) of an internal combustion engine (1) according to claim 1, wherein the groove (35) is formed from a lateral concaved part (351) that runs to a downstream side and is concaved from an inner circumferential surface of the intake path (3) to outside, and a lateral convex part (352) that runs adjacently to the lateral concaved part (351) and projects inwards from the inner circumferential surface of the intake path (3).

3. The intake system(2) of an internal combustion engine (1) according to claim 2,

wherein the groove (35) has a groove top face (353) formed from a top face of the lateral concaved part (351), and a groove bottom face (354) formed from a bottom face of the lateral concaved part (351) and a top face of the lateral convex part (352), by the lateral convex part (352) being provided at a lower side of the lateral concaved part (351), and

wherein a length of the groove bottom face (354) is longer than a length of the groove top face (353) in a cross section in a direction orthogonal to a center line of the intake path (3).

4. The intake system (2) of an internal combustion engine (1) according to any one of claims 1 to 3, further comprising a partition wall (7) that runs along the groove (35) towards a downstream side until midway of the groove (35) with the merging part (33) as a starting point, and separates and divides the intake path (3) and the EGR path (4).

5. The intake system (2) of an internal combustion engine (1) according to claim 4, wherein a convex part (71) projecting inwards of the intake path (3) is provided at a leading end of the partition wall (7).

6. The intake system (2) of an internal combustion engine (1) according to claim 4 or 5, wherein a concaved part (72) is provided in a face of the partition wall (7) on a side facing the intake path (3).

7. The intake system (2) of an internal combustion engine (1) according to claim 6, wherein the concaved part (72) runs towards an upstream side.

8. The intake system (2) of an internal combustion engine (1) according to claim 6 or 7, wherein the concaved part (72) connects with the groove (35) by being provided to join with a side face in which the groove (35) is provided.

9. The intake system (2) of an internal combustion engine (1) according to any one of claims 6 to 8,

wherein the concaved part (72) is provided to be disjoined from an opposing side face (32) that opposes a side face in which the groove (35) is provided, and

wherein a curved face (38) that curves from the concaved part (72) to an upstream side towards the opposing side face (32) is provided between the opposing side face (32) and the concaved part (72).

10. The intake system (2) of an internal combustion engine (1) according to any one of claims 1 to 9, further comprising:

a compressor that charges fresh air; and a recirculation means for recirculating blow-by oil to upstream of the compressor,

wherein the merging part (33) is disposed between the compressor and an intake manifold (6).

11. The intake system (2) of an internal combustion engine (1) according to any one of claims 1 to 10, further comprising an EGR valve (41) provided midway of the EGR path (4) and controlling a flowrate of the EGR gas,

wherein the EGR path (4) slopes downwards from the EGR valve (41) towards the merging part (33).

Dated this 05 day of February 2013

Anand Barnabas
REG.NO:IN/PA-974
of De Penning & De Penning
Agent for the Applicants

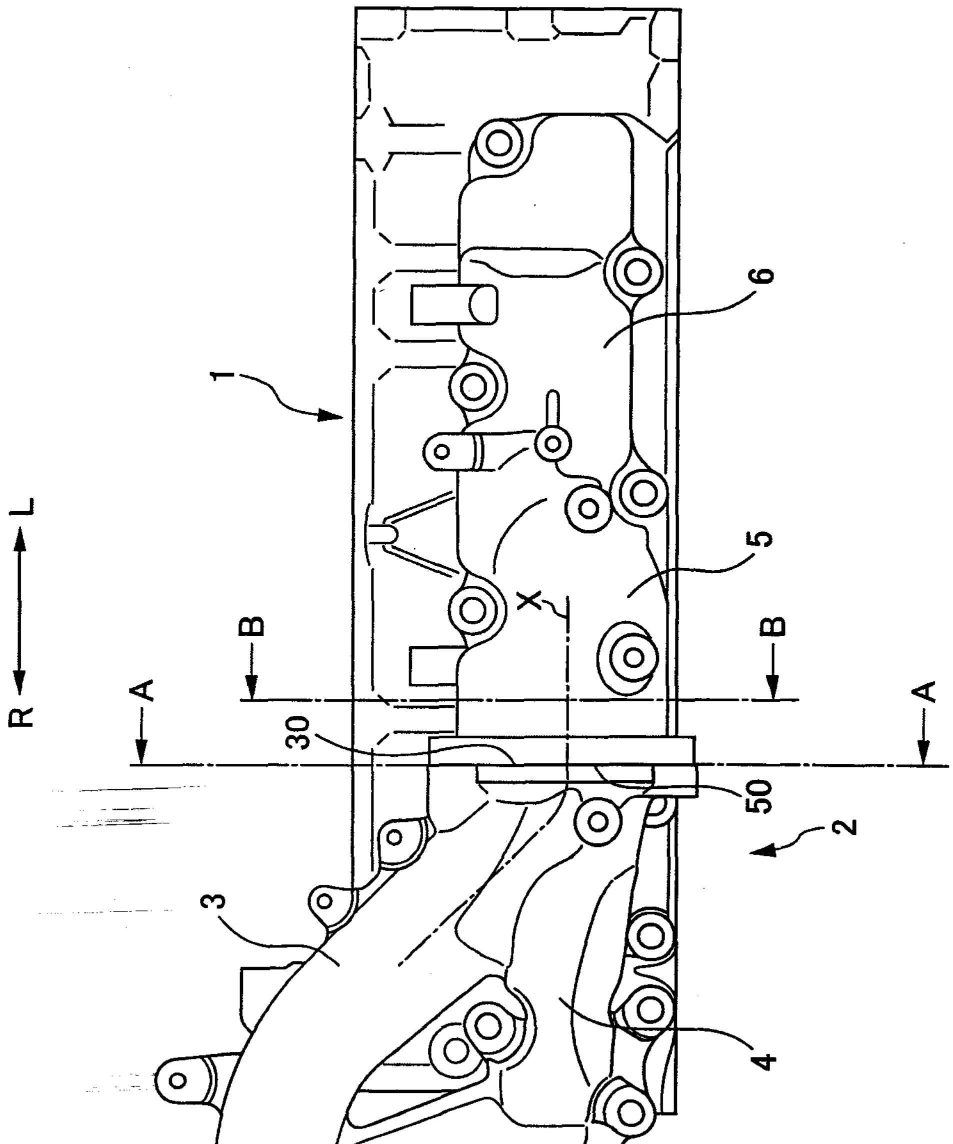



FIG. 1

(Anand Barnabas)
REG. NO.: IN/PA – 974
Of De Penning & De Penning
Agent for the Applicants

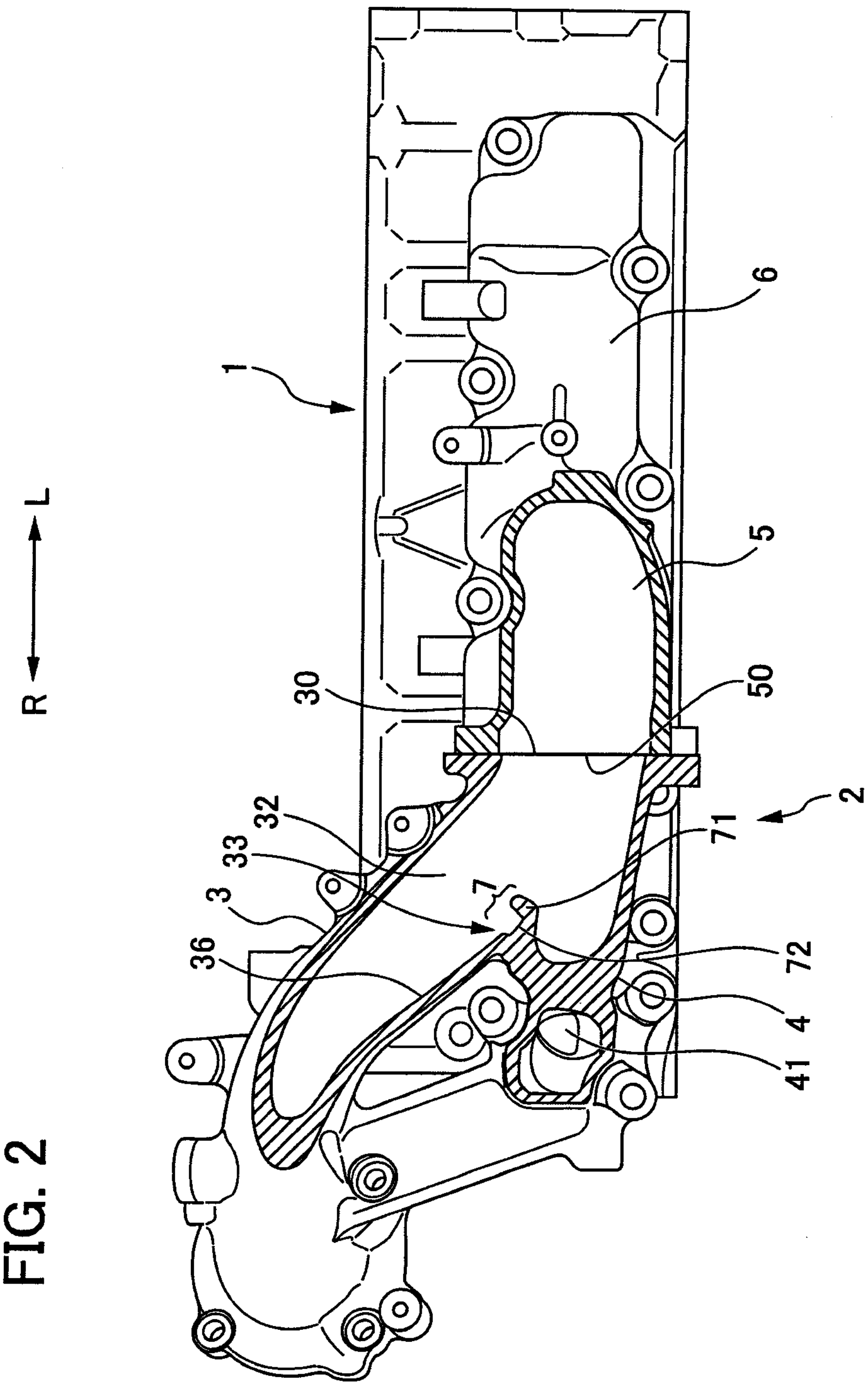
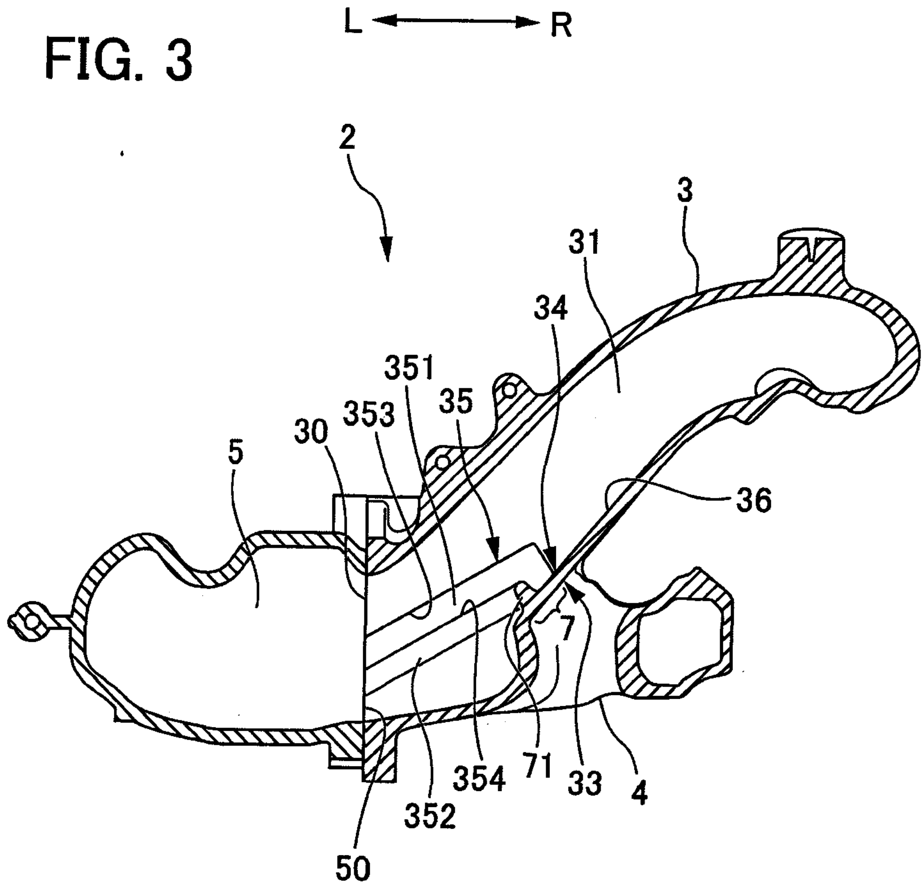



FIG. 2

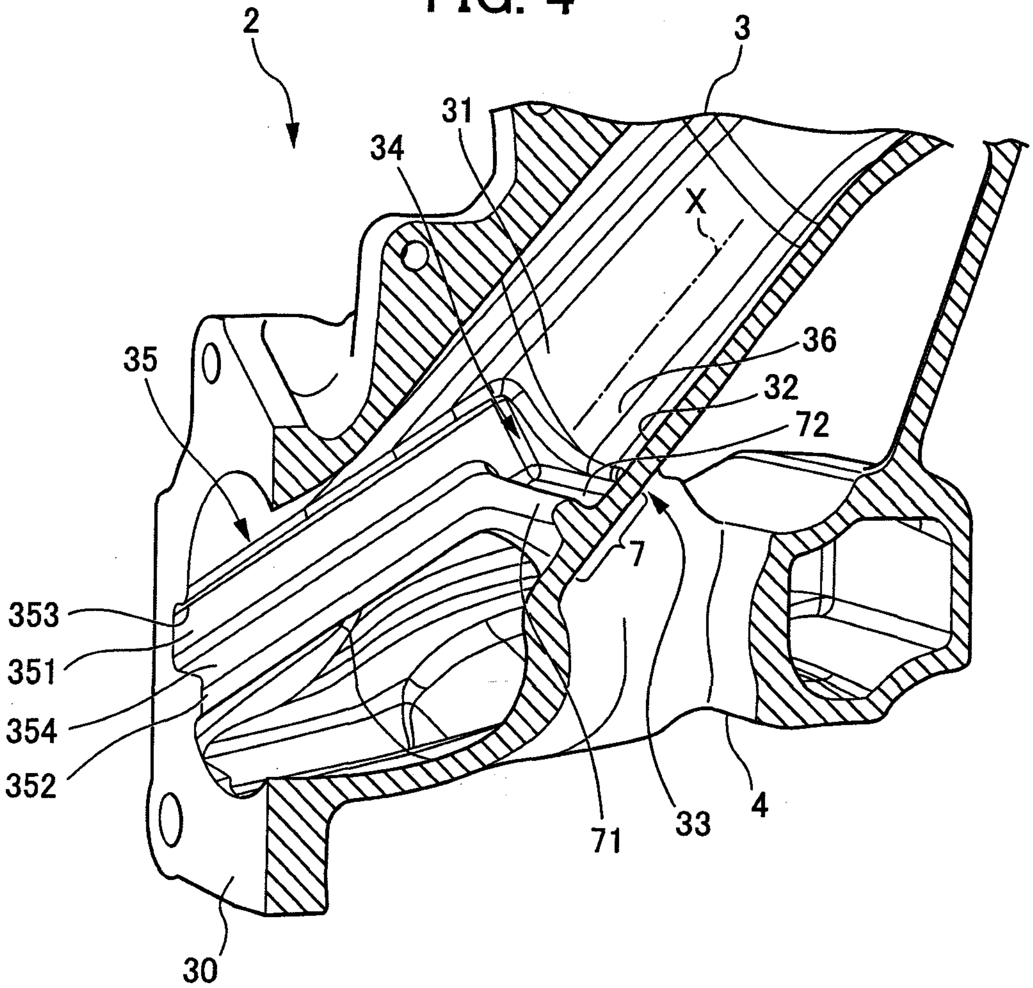
(Anand Barnabas)
REG. NO.: IN/PA – 974
Of De Penning & De Penning
Agent for the Applicants

FIG. 3



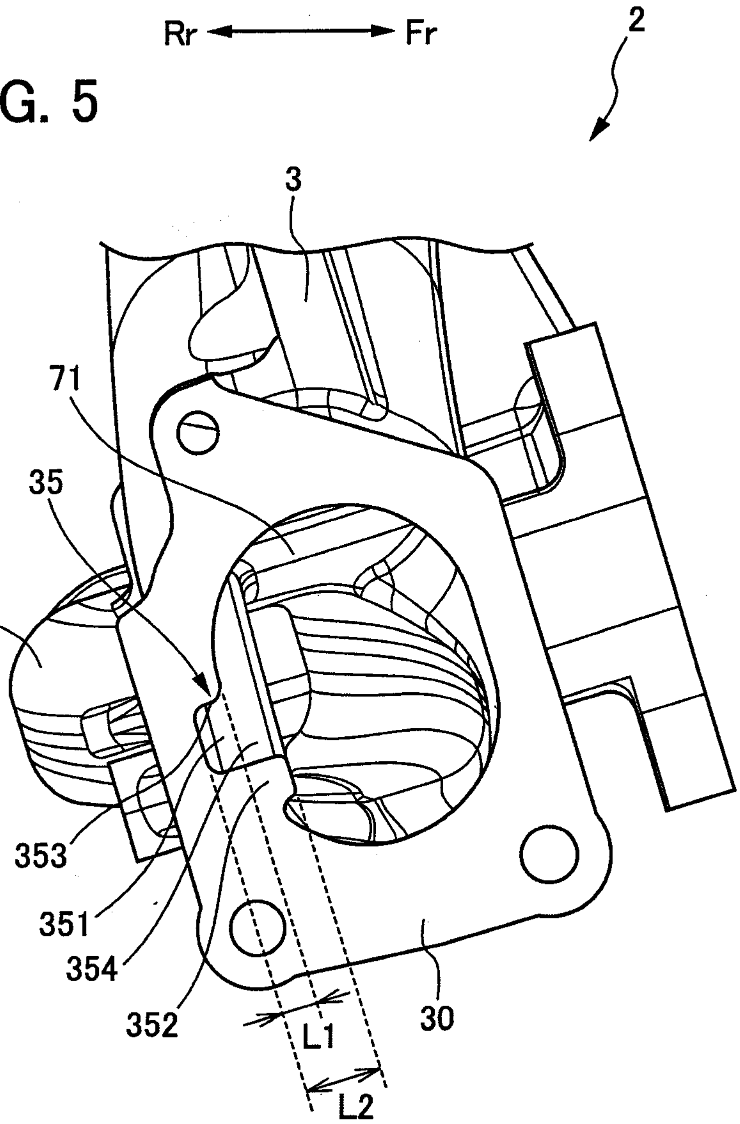

(Anand Barnabas)
REG. NO.: IN/PA – 974
Of De Penning & De Penning
Agent for the Applicants

FIG. 4




(Anand Barnabas)
REG. NO.: IN/PA – 974
Of De Penning & De Penning
Agent for the Applicants

FIG. 5




(Anand Barnabas)
REG. NO.: IN/PA – 974
Of De Penning & De Penning
Agent for the Applicants

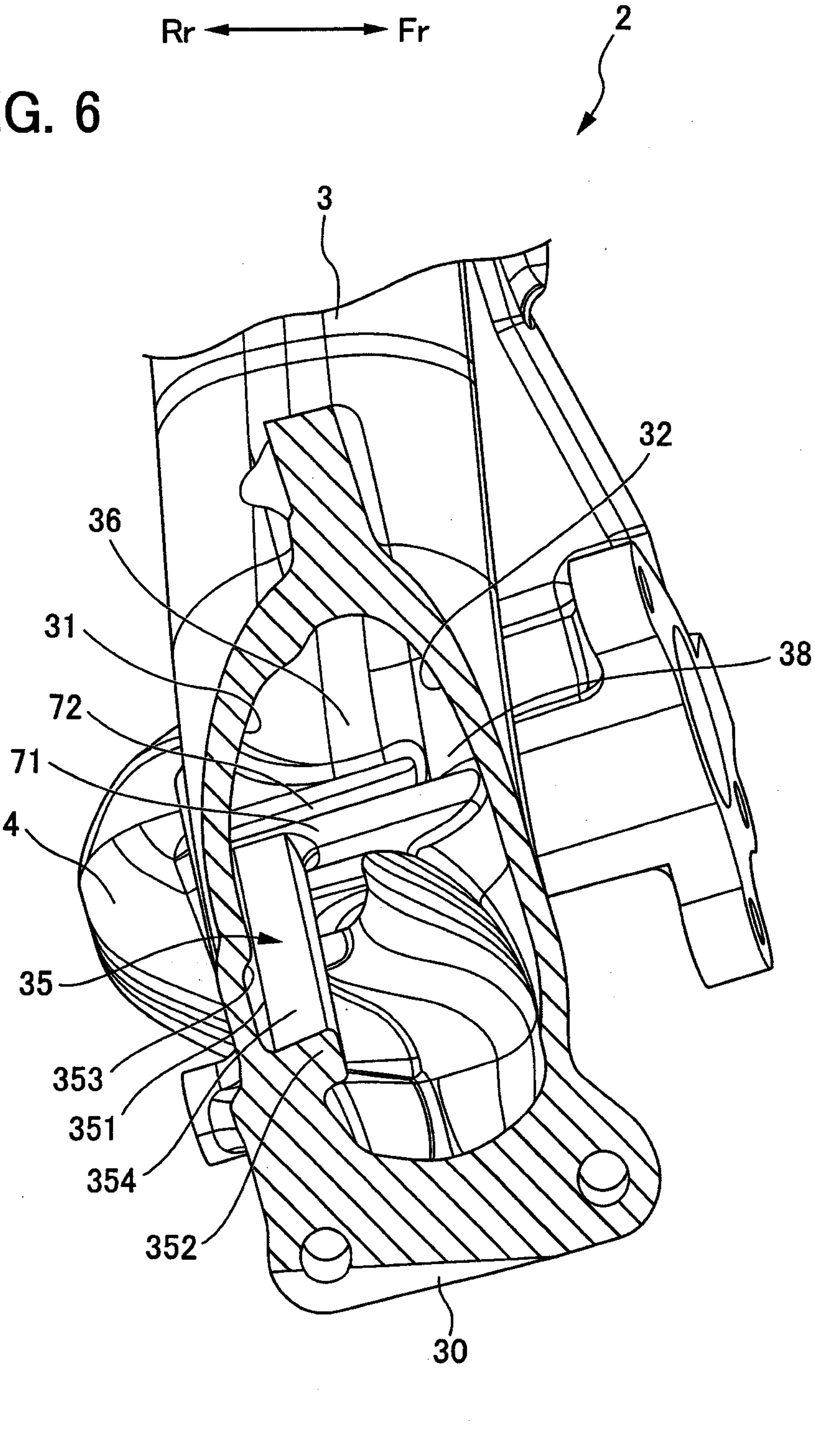
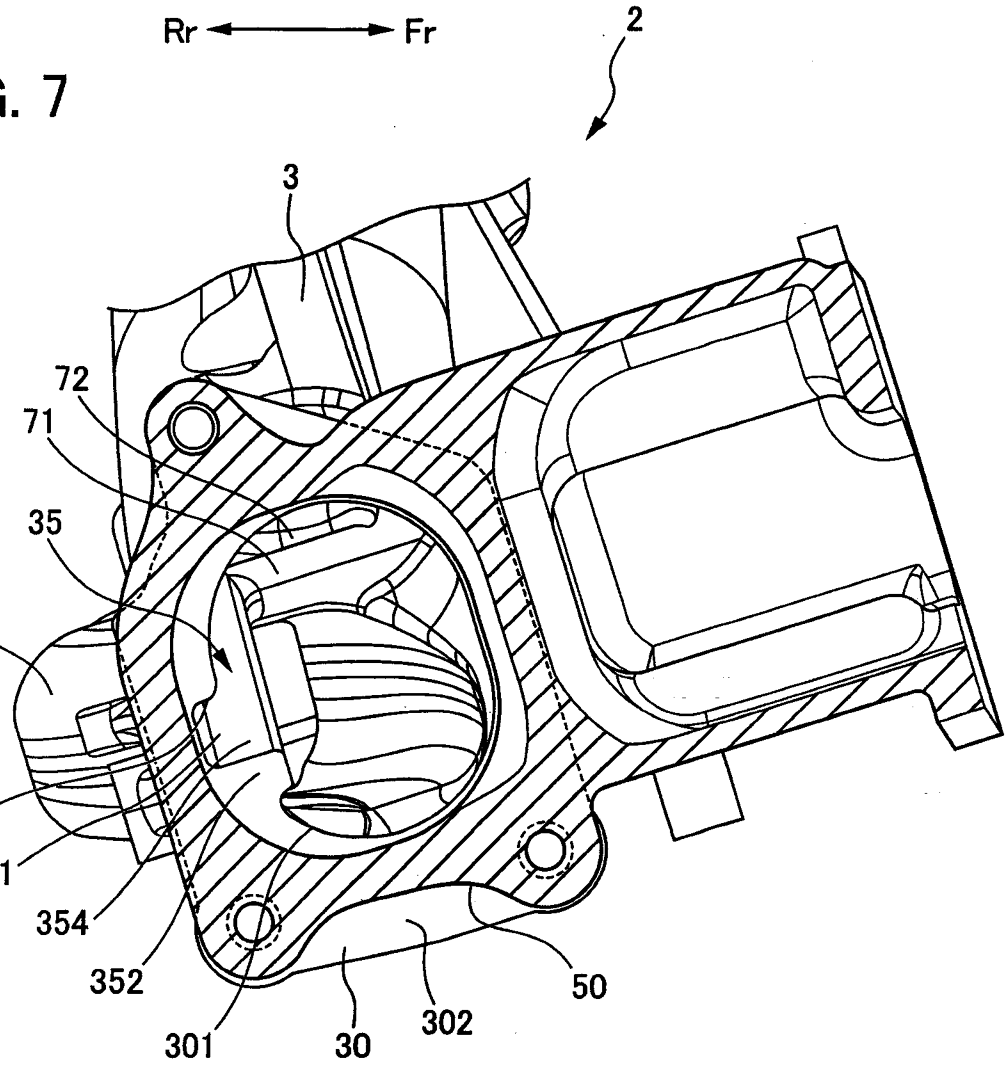



FIG. 6

(Anand Barnabas)
REG. NO.: IN/PA – 974
Of De Penning & De Penning
Agent for the Applicants

Rr ⟵⟶ Fr

FIG. 7




(Anand Barnabas)
REG. NO.: IN/PA – 974
Of De Penning & De Penning
Agent for the Applicants

# INTAKE SYSTEM OF INTERNAL COMBUSTION ENGINE

This application is based on and claims the benefit of priority from Japanese Patent Application No. 2012-025481, filed on 8 February 2012, the content of which is incorporated herein by reference.

## BACKGROUND OF THE INVENTION

### Field of the Invention

The present invention relates to an intake system of an internal combustion engine. More specifically, the present invention relates to an intake system of an internal combustion engine including an intake path, and an EGR path that merges with the intake path from below.

### Related Art

Conventionally, the intake system of an internal combustion engine includes an intake path that supplies fresh air to the combustion chambers, and an EGR path that recirculates a part of the exhaust from an exhaust path to the intake path as EGR gas. An EGR valve that controls the flowrate of EGR gas is provided midstream of the EGR path.

However, in the intake path or an intake manifold to which the intake path is connected, blow-by gas and EGR gas is recirculated; therefore, foreign contaminants such as blow-by oil, condensed water and carbon (hereinafter referred to as "oil, etc.") are present. There is concern over an operational malfunction of the EGR valve occurring when this oil, etc. permeates into the EGR path and adheres to the EGR valve. In particular, if blow-by oil and carbon adhere to the EGR valve, operational malfunction will occur by tarring and becoming solid form, and the EGR valve sticking.

Therefore, a technique has been proposed of joining the EGR path to a surge tank integrally molded with the intake manifold from below, and having the EGR path slope downwards from the EGR valve towards the surge tank, and then having the EGR path slope back upwards towards the surge tank (refer to Patent Document 1). According to this technology, a bend is formed inside of the EGR path at a position lower than the EGR valve, and this bend functions as a collector of the oil, etc. Since the oil, etc. is thereby collected in the bend, even if trickling from the surge tank and permeating inside of the EGR path, it is said to be able to avoid adherence to the EGR valve.

In addition, a technology has been proposed that has the EGR path merge in the vicinity of a joining end face with the combustion chamber of the intake runner provided in the intake manifold (refer to Patent Document 2). With this technology, a leading end face of the EGR path is made to slope in the opposite direction to the intake flow direction more than a joining end face of the intake runner, and a barrier wall separating the intake runner and EGR path runs until near the joining end face with the combustion chamber. It is said to thereby be possible to discharge foreign contamination such as carbon and condensed water produced from the EGR gas being cooled by the EGR cooler provided inside the EGR path in the intake smoothly along with EGR gas, since the EGR gas flow is hardly resistance to the intake flow. In addition, due to being a structure in which oil, etc. will not easily permeate inside of the EGR path even if blow back occurs, it is said to be able to avoid operational malfunction of the EGR valve from adherence of oil, etc.

[Patent Document 1] Japanese Patent No. 3424720

[Patent Document 2] Japanese Unexamined Patent Application, Publication No. 2009-209855

SUMMARY OF THE INVENTION

However, with the technology of Patent Document 1, condensed water occurring in abundance by the EGR gas being cooled by the EGR cooler, particularly during engine startup, may collect in the bend without being discharged into the intake air; therefore, the oil, etc. having collected in the bend will flow backwards from the pulsation of the EGR gas and reach the EGR valve, and the aforementioned such operational malfunction of the EGR valve may occur. In addition, since oil, etc. does not naturally flow out, but rather stagnates for a long period of time in the bend and EGR valve, the inside of the EGR path and the EGR valve may corrode and deteriorate. Furthermore, since the EGR path is arranged below the surge tank, the oil, etc. may permeate from the surge tank into the EGR path during engine stop, and flow into the EGR valve.

In addition, with the technology of Patent Document 2, in addition to causing the EGR path to merge with the intake runner provided to the intake manifold, the barrier wall separating the intake runner and the EGR path runs until the vicinity of a joining end face with the combustion chamber; therefore, the EGR gas cannot be well mixed with fresh air, and the emissions (EM) may degrade.

The present invention has been made taking the above into account, and an object thereof is to provide an intake system of an internal combustion engine that can satisfactorily mix EGR gas with fresh air, while avoiding operational malfunction occurring from oil, etc. permeating inside of the EGR path and adhering to the EGR valve.

In order to achieve the above-mentioned object, the present invention provides an intake system of an internal combustion engine (e.g., the intake system 2 described later) disposed to be sloped relative to a horizontal plane upon mounting to a vehicle, the system including: an intake path (e.g., the intake pipe 3 described later) that supplies fresh air to a combustion chamber of the internal combustion engine; and an EGR path (e.g., the EGR pipe 4 described later) that merges with the intake path from below, and recirculates a portion of exhaust gas from an exhaust path (e.g., the exhaust plumbing described later) of the internal combustion engine (e.g., the engine 1 described later) to the intake path as EGR gas. In the intake system of the internal combustion engine according to the present invention, among both side faces (e.g., the side faces 31 and 32 described later) of the intake path, a side face (e.g., the side face 31 described later) positioned below includes a groove (e.g., the groove 35 described later) that extends to a downstream side, by beginning at a junction (e.g., the first junction 34a described later) between the side face and a merging part (e.g., the merging part 33 described later) at which the EGR path merges with the intake path prior to merging, or by passing from a side further upstream than the junction through the junction.

With the present invention, among both side faces of the intake path in the intake system of an internal combustion engine including the EGR path that merges with the intake path from below and is disposed to be sloped relative to a horizontal plane upon mounting to a vehicle, the groove is provided in the side face positioned below. In more detail, the groove extending to a downstream side is provided by beginning at the junction, which is a junction between the merging part at which the EGR path merges with the intake path prior to merging, and the side face positioned below, or by passing from a side further upstream than the junction through the junction.

The oil, etc. flowing through the inside of the intake path along with fresh air is thereby led to an intake manifold (combustion chamber) side by flowing inside of the groove provided in the side face positioned below. Therefore, it is possible to avoid the oil, etc. permeating inside of the EGR path from the merging part and adhering to the EGR valve, and it is possible to avoid the occurrence of an operational malfunction of the EGR valve and degradation of the EGR valve.

In addition, in the present invention, since it is possible to avoid the oil, etc. from permeating from the merging part to inside of the EGR path by providing the groove in the side face of the intake pipe, a barrier wall to separate between the intake path and EGR path as in Patent Document 2 is not necessarily required. Therefore, according to the present invention, it is possible to satisfactorily mix EGR gas with fresh air.

In this case, it is preferable for the groove to be formed from a lateral concaved part (e.g., lateral concaved part 351 described later) that runs to a downstream side and is concaved from an inner circumferential surface of the intake path to outside, and a lateral convex part (e.g., the lateral convex part 352 described later) that runs adjacently to the lateral concaved part and projects inwards from the inner circumferential surface of the intake path.

In the present invention, the groove is formed by the lateral concaved part that runs to a downstream side and is concaved from the inner circumferential surface of the intake path to outside, and the lateral convex part running adjacently to the lateral concaved part and projecting inwards from the inner circumferential surface of the intake path.

Herein, in a case of forming the groove with only the lateral concaved part, if the cavity of the lateral concaved part is made large to ensure the depth of the groove, it will be necessary to thicken the wall thickness from the viewpoint of maintaining strength. In addition, in a case of forming the groove with only the lateral convex part, if the projection of the lateral convex part is made large to ensure the depth of the groove, the flows of fresh air and EGR gas will be disturbed and pressure loss and turbulence will arise, a result of which the EGR gas cannot be satisfactorily mixed with the fresh air.

In contrast, according to the present invention, by forming the groove by combining the lateral concaved part and the lateral convex part, it is possible to reduce the wall thickness while ensuring the depth of the groove, and it is possible to suppress degradation of the mixing of EGR gas with the fresh air. In addition, since it is possible to adequately ensure the depth of the groove, oil, etc. is more reliably led to the intake manifold (combustion chamber) side by flowing inside of the groove. Therefore, according to the present invention, it is possible to more reliably avoid oil, etc. from permeating from the merging part to inside of the EGR path, and it is possible to more reliably avoid the occurrence of operational malfunction of the EGR valve and degradation of the EGR valve.

In this case, it is preferable for the groove to have a groove top face (e.g., the groove top face353 described later) formed from a top face of the lateral concaved part, and a groove bottom face (e.g., the groove bottom face 354 described later) formed from a bottom face of the lateral concaved part and a top face of the lateral convex part, by the lateral convex part being provided at a lower side of the lateral concaved part, and for a length (e.g., the length L2 described later) of the groove bottom face to be longer than a length (e.g., the length L1 described later) of the groove top face in a cross section in a direction orthogonal to a center line of the intake path (e.g., the center line X described later).

In the present invention, by providing the lateral convex part on a lower side of the lateral concaved part, the groove top face is formed from the top face of the lateral concaved part, and the groove bottom face is formed from the bottom face of the lateral concaved part and the top face of the lateral convex part. In addition, in a cross section in a direction orthogonal to the center line of the intake path, the length of the groove bottom face is set to be longer than the length of the groove top face.

Since oil, etc. flowing inside of the intake path flows along the groove bottom face, the length of the groove bottom face (i.e. depth of the groove) can be ensured to be larger according to the present invention. Therefore, according to the present invention, it is possible to more reliably avoid oil, etc. from permeating from the merging part to inside of the EGR path, and adhering to the EGR valve, and it is possible to more reliably avoid the occurrence of operational malfunction of the EGR valve and degradation of the EGR valve.

In this case, it is preferable to further include a partition wall (e.g., the partition wall 7 described later) that runs along the groove towards a downstream side until midway of the groove with the merging part as an origin, and separates and divides the intake path and the EGR path.

In the present invention, the partition wall dividing and separating the intake path and EGR path runs along the groove to a downstream side until midway of the groove, with the merging part as the origin.

It is thereby possible to avoid oil, etc. from permeating inside of the EGR path by way of the partition wall, even in a case of oil, etc. not having flowed from the base end side of the groove to inside of the groove. In addition, since the partition wall is only provided along the groove until midway of the groove, it is possible to suppress deterioration in the mixing of the EGR gas with the fresh air.

In this case, it is preferable for a convex part (e.g., the convex part 71 described later) projecting inwards of the intake path to be provided at a leading end of the partition wall.

In the present invention, the convex part projecting inwards of the intake path is provided to a leading end of the partition wall. It is thereby possible to suppress oil, etc. flowing inside of the intake path from permeating inside of the EGR path. In particular, since there is no flow of intake air in the intake path 3 while the engine is stopped, there is concern over oil, etc. trickling into the EGR path; however, this can be avoided according to the present invention.

In this case, it is preferable for a concaved part (e.g., the concaved part 72 described later) to be provided in a face of the partition wall on a side facing the intake path.

In the present invention, the concaved part is provided to a face of the partition wall on a side facing the intake path. It is thereby possible to more reliably avoid oil, etc. from permeating inside of the EGR path, since the oil, etc. flowing inside of the intake path can be made to stagnate in this concaved part. In particular, there is no flow of intake air inside of the intake path while the engine is stopped; therefore, there is concern over oil, etc. trickling inside of the EGR path; however, this can be reliably avoided according to the present invention.

In this case, it is preferable for the concaved part to run from the partition wall towards an upstream side.

In the present invention, the concaved part is run from the partition wall toward the upstream side. Since oil, etc. flowing through inside of the intake path can be made to more reliably stagnate in the concaved part, oil, etc. can more reliably be avoided from permeating inside of the EGR path.

In this case, it is preferable for the concaved part to connect with the groove by being provided to join with a side face in which the groove is provided.

According to the present invention, the groove and concaved part are connected by joining the concaved part to the side face in which the groove is provided. Since oil, etc. stagnated in the concaved part can thereby be led to the groove, oil, etc. can more reliably be avoided from permeating inside of the EGR path.

In this case, it is preferable for the concaved part to be provided to be disjoined from an opposing side face (e.g., the side face 32 described later) that opposes a side face in which the groove is provided, and a curved face (e.g., the curved face 38 described later) that curves from the concaved part to an upstream side towards the opposing side face to be provided between the opposing side face and the concaved part.

In the present invention, the curved face curving from the concaved part to an upstream side towards the opposing side face is provided between the concaved part and the opposing side face, without joining the concaved part to the opposing side face opposing the side face in which the groove is provided. Since the oil, etc. is thereby more reliably led from the concaved part to the groove by following the curved face, oil, etc. can be more reliably avoided from permeating inside of the EGR path.

In this case, it is preferable to further include: a compressor that charges fresh air; and a recirculation means for recirculating blow-by oil to upstream of the compressor, in which the merging part is disposed between the compressor and an intake manifold (e.g., the intake manifold 6 described later).

In the present invention, the merging part is provided between the compressor and the intake manifold in the intake system of an internal combustion engine equipped with the compressor and the recirculation means for recirculating blow-by oil to upstream of the compressor. In the case of recirculating blow-by oil to upstream of the compressor in a pressure relationship as in a diesel engine, an abundance of blow-by oil flows inside of the intake path; therefore, the above-mentioned effect of the present invention is further raised by providing the groove in the side face of such an intake path. In addition, since the merging part between the intake path and EGR path is provided between the compressor and the intake manifold according to the present invention, the distance from the merging part to the combustion chamber can be ensured, and the EGR gas can be more satisfactorily mixed with fresh air compared to Patent Document 2.

In this case, it is preferable to further include an EGR valve (e.g., the EGR valve 41 described later) provided midway of the EGR path and controlling a flowrate of the EGR gas, in which the EGR path slopes downwards from the EGR valve towards the merging part.

In the present invention, the EGR path is made to slope downwards from the EGR valve towards the merging part. Since there is no collector of oil, etc. inside of the EGR path from the EGR valve to the merging part, the oil, etc. can thereby be avoided from collecting inside the EGR path. In addition, even in a case of oil, etc. trickling and permeating inside the EGR path while the engine is stopped, for example, the oil, etc. will not flow into the EGR valve due to the EGR path from the EGR valve to the merging part being a hanging structure sloped downwards. Therefore, according to the present invention, oil, etc. can more reliably be avoided from adhering to the EGR valve, and thus the occurrence of operational malfunction of the EGR valve and degradation of the EGR valve can be more reliably avoided.

According to the present invention, it is possible to provide an intake system of an internal combustion engine that can satisfactorily mix EGR gas with fresh air, while avoiding operational malfunction occurring from oil, etc. permeating inside the EGR path and adhering to the EGR valve.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side view of an intake system of an internal combustion engine according to an embodiment of the present invention;

FIG. 2 is a diagram viewing a longitudinal section of the intake system according to the embodiment from a rear side of a vehicle body;

FIG. 3 is a diagram viewing a longitudinal section of the intake system according to the embodiment from an angle at the front side of the vehicle body;

FIG. 4 is a diagram viewing a longitudinal section of an intake path and EGR path of the intake system according to the embodiment from a front side of the vehicle body;

FIG. 5 is a cross-sectional view along the line A-A in

FIG. 1;

FIG. 6 is a diagram viewing a partial cross section of the intake path of the intake system according to the embodiment from above at an angle; and

FIG. 7 is a cross-sectional view along the line B-B in FIG. 1.

## DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, an embodiment of the present invention will be explained while referencing the drawings.

FIG. 1 is a side view of an intake system 2 of an internal combustion engine 1 according to the embodiment of the present invention. In addition, FIG. 2 is a diagram viewing a longitudinal section of the intake system 2 of the internal combustion engine 1 from outside, and FIG. 3 is a diagram viewing a longitudinal section of the intake system 2 of the internal combustion engine 1 from a side of the internal combustion engine 1.

In FIGS. 1 to 3, the L direction indicates the right-hand side of the vehicle body, and the R direction indicates the left-hand side of the vehicle body (the same applies to the following). As shown in FIGS. 1 to 3, in the intake system 2 of the internal combustion engine (hereinafter referred to as "engine") 1, the engine 1 is arranged on the front side of the vehicle body, and the intake system 2 is arranged at the rear side of the vehicle body. Upon being mounted to a vehicle, the intake system 2 of the engine 1 according to the present embodiment is arranged to be sloped 15° to a rearward side relative to a horizontal plane (out of the page of FIGS. 1 and 2, and into the page of FIG. 3).

The engine 1 is an in-line four-cylinder diesel engine. Intake air is supplied from the intake system 2 described later to the combustion chamber of each cylinder, which is not illustrated, and fuel is directly injected by fuel injectors that are not illustrated, provided to each cylinder. The exhaust produced from combustion is discharged by exhaust plumbing that is not illustrated.

As shown in FIGS. 1 to 3, the intake system 2 is configured to include an intake pipe 3, an EGR pipe 4, an intake port 5, and an intake manifold 6.

The intake pipe 3 is an intake path for supplying fresh air to the combustion chambers of the engine 1. The intake pipe 3 is provided to extend from above the EGR pipe 4 described later, obliquely downwards. The intake pipe 3 is joined to the intake port 5 by a leading end face 30 thereof being joined to a joining face 50 of the intake port 5.

In the present embodiment, a compressor, which is not illustrated, charging fresh air is provided to an intake pipe on a further upstream side from the intake pipe 3 shown in FIGS. 1 to 3. In addition, a recirculation pipe that is not illustrated, recirculating blow-by oil, merges with an intake pipe on a further upstream side of the compressor. Foreign contamination such as a large amount of blow-by oil, condensed water and carbon thereby flows through to the intake pipe 3.

In addition, a merging part 33 described later comes to be provided between the compressor and the intake manifold 6.

The EGR pipe 4 described later merges to the intake pipe 3 from below. The intake pipe 3 and EGR pipe 4 merge at an acute angle, and are thereby configured so that the intake flow and EGR gas flow do not impinge and the flows do not disturb each other.

In addition, the merging part 33 between the EGR pipe 4 and intake pipe 3 is formed by the EGR pipe 4 joining with the intake pipe 3 before merging.

Among both side faces 31 and 32 of the intake pipe 3, a groove 35 is provided in the side face 31 disposed at the rear side of the vehicle body and positioned below by the intake system 2 of the engine 1 being disposed sloped 15° to the rear side.

FIG. 4 is a diagram viewing a longitudinal section of the intake pipe 3 and EGR pipe 4 of the intake system 2 of the engine 1 at an angle on a front side of the vehicle body.

As shown in FIGS. 3 and 4, the groove 35 runs to a downstream side, with a junction 34, which is a junction between the merging part 33 and the side face 32, as the origin. The groove 35 slopes downwards towards the side of the intake port 5, and is formed from a lateral concaved part 351 and a lateral convex part 352.

The lateral concaved part 351 extends obliquely downwards towards a downstream side, and is concaved from an inner circumferential surface of the intake pipe 3 towards outside.

The lateral convex part 352 extends adjacently to the lateral concaved part 351, and projects inwards from the inner circumferential surface of the intake pipe 3.

In the present embodiment, the lateral convex part 352 is provided on a lower side of the lateral concaved part 351. A groove top face 353 of the groove 35 is formed by the top face of the lateral concaved part 351. In addition, a groove bottom face 354 of the groove 35 is formed by the bottom face of the lateral concaved part 351 and top face of the lateral convex part 352.

Furthermore, as shown in FIGS. 3 and 4, a partition wall 7 dividing and separating the intake pipe 3 and EGR pipe 4 is provided at the merging part 33. The partition wall 7 is run towards a downstream side along the groove 35 until midway of the groove 35, with the merging part 33 as the starting point, and is joined to both side faces 31 and 32 of the intake pipe 3. Degradation in the mixing between fresh air and EGR gas is thereby suppressed, while oil, etc. is suppressed from trickling from the intake pipe 3 side of the merging part 33 and permeating into the EGR pipe 4.

A convex part 71 projecting inwards of the intake pipe 3 is provided at a leading end on the downstream side of the partition wall 7. The convex part 71 is joined with the side face 31 (groove 35) and side face 32, and is provided to project more inwards than the inner circumferential surface of the intake pipe 3. Oil, etc. is thereby avoided from trickling from the intake pipe 3 side of the merging part 33 and permeating inside of the EGR pipe 4.

Herein, since the partition wall 7 is run to a downstream side, there is a limitation upon manufacture. More specifically, the intake pipe 3 is produced by casting using a sand core; however, since it is necessary for the thickness of the partition wall to be at least twice the running length, there is a limit in the running length. In contrast, by providing the convex part 71 at the leading end of the partition wall 7, it becomes easy to ensure the running length of the partition wall 7.

FIG. 5 is a cross-sectional view along the line A-A in FIG. 1, and is a cross-sectional view orthogonal the center line X of the intake pipe 3. However, for convenience, FIG. 5 is illustrated by omitting the engine 1 and parts of the intake pipe 3. In addition, in FIG. 5, the Fr direction indicates forwards of the vehicle body front, and the Rr direction indicates rearwards of the vehicle body (the same applies to the following).

As shown in FIG. 5, in the cross section in the direction orthogonal to the center line X of the intake pipe 3, the length (depth) L2 of the groove bottom face 354 of the groove 35 is designed to be longer than the length (depth) L1 of the groove top face 353. The depth of the groove 35 is thereby adequately ensured.

Referring back to FIG. 4, a concaved part 72 is provided to a surface of the partition wall 7 on a side facing the intake path. The concaved part 72 is provided along the convex part 71 provided at the leading end of the partition wall 7, and is joined to the side face 31 of the intake pipe 3 in which the groove 35 is provided. The aforementioned groove 35 is provided beginning at the junction 34, which is a junction between the merging part 33 and the side face 32; therefore, the concaved part 72 becomes a structure connected with the groove 35. By the oil, etc. flowing through the intake pipe 3 stagnating in the concaved part 72, the oil, etc. is thereby suppressed from trickling from the intake pipe 3 side of the merging part 33 and permeating inside of the EGR pipe 4.

It should be noted that, at an upstream side end of the groove 35, i.e. portion joining with the concaved part 72, the groove 35 is formed by only the lateral concaved part 351, without the lateral convex part 352 being provided. It thereby becomes easier for the oil, etc. stagnated in the concaved part 72 to flow into the groove 35.

FIG. 6 is a diagram viewing a partial cross section of the intake pipe 3 of the intake system 2 at an angle from above. As shown in FIG. 6, the concaved part 72 does not reach so far as the side face 32 opposing the side face 31 in which the groove 35 is provided, and is not joined to the side face 32. A curved face 38 curving from the concaved part 72 to an upstream side towards the side face 32 is provided between the concaved part 72 and the side face 32. The curved face 38 is formed by making an end of the concaved part 72 on the side face 32 side into an R shape.

FIG. 7 is a cross-sectional view along the line B-B in

FIG. 1. However, for convenience, FIG. 7 is illustrated by omitting the engine 1 and a part of the intake pipe 3.

As shown in FIG. 7, a leading end face 30 of the intake pipe 3 is formed from an opening 301 communicating with a space inside of the intake pipe 3, and a flange face 302 running outwards in the radial direction from the outer circumference of the intake pipe 3 over the entire periphery.

In contrast, a joining face 50 of the intake port 5 takes on a shape close to the above-mentioned flange face 302, and has an opening 501 that is larger than the above-mentioned opening 301. The oil, etc. arriving by flowing inside of the groove 35 is thereby not obstructed from flowing into the intake port 5.

Referring back to FIG. 2, the EGR pipe 4 is a path for recirculating a part of the exhaust gas from the exhaust plumbing of the engine 1 to the intake pipe 3 as EGR gas. As explained above, the EGR pipe 4 merges with the intake pipe 3 from below.

The upstream side of the EGR pipe 4 is joined to a head-internal EGR pipe extending from the exhaust manifold (not illustrated) into the cylinder head. Since coolant circulates in the cylinder head, the EGR gas flowing through the head-internal EGR pipe is cooled without providing a special EGR cooler, whereby condensed water is produced.

The EGR valve 41 that controls the flowrate of EGR gas flowing inside of the EGR pipe 4 is provided between the EGR pipe 4 and the above-mentioned head-internal EGR pipe. The EGR valve 41 controls the flowrate of EGR gas flowing inside of the EGR pipe 4 by being controlled by an ECU that is not illustrated to be made to change the cross-sectional area of the EGR pipe 4.

The EGR pipe 4 makes a hanging structure sloped downwards, from a position at which the EGR valve 41 is provided towards the merging part 33 with the intake pipe 3. The EGR valve 41 is thereby disposed above the merging part 33.

In addition, as shown in FIG. 4, the EGR pipe 4 makes a curved structure having turn-back part that curves and turns back in a sectional view in a substantially horizontal direction. Oil, etc. is thereby suppressed from permeating inside of the EGR pipe 4.

After fresh air and EGR gas has been introduced to the intake port 5 and intake manifold 6 by the above explained intake pipe 3 and EGR pipe 4 in a well-mixed state, it is supplied into the combustion chamber of each cylinder and offered for combustion.

The following operational effects are exerted according to the intake system 2 according to the present embodiment having the above configuration.

First, with the present embodiment, among both side faces 31 and 32 of the intake pipe 3 in the intake system 2 of the engine 1 including the EGR pipe 4 that merges with the intake pipe 3 from below and is disposed to be sloped relative to a horizontal plane upon mounting to a vehicle, the groove 35 is provided in the side face 31 positioned below. In more detail, the groove 35 extending to a downstream side is provided beginning at the junction 34, which is a junction between the merging part 33 at which the EGR pipe 4 merges with the intake pipe 3 prior to merging, and the side face 31 positioned below.

The oil, etc. flowing through the inside of the intake pipe 3 along with fresh air is thereby led to an intake manifold 6 (combustion chamber) side by flowing inside of the groove 35 provided in the side face 31 positioned below. Therefore, it is possible to avoid the oil, etc. permeating inside of the EGR pipe 4 and adhering to the EGR valve 41, and it is possible to avoid the occurrence of an operational malfunction of the EGR valve 41 and degradation of the EGR valve 41.

In addition, in the present embodiment, since it is possible to avoid the oil, etc. from trickling from the intake pipe 3 side of the merging part 33 and permeating inside of the EGR pipe 4 by providing the groove 35 in the side face 31 of the intake pipe 3, a barrier wall to separate between the intake path and EGR path as in Patent Document 2 is not necessarily required. Therefore, according to the present embodiment, it is possible to satisfactorily mix EGR gas with fresh air.

In addition, in the present embodiment, the groove 35 is formed by the lateral concaved part 351 that runs to a downstream side and is concaved from the inner circumferential surface of the intake pipe 3 to outside, and the lateral convex part 352 running adjacently to the lateral concaved part 351 and projecting inwards from the inner circumferential surface of the intake pipe 3.

Herein, in a case of forming the groove 35 with only the lateral concaved part 351, if the cavity of the lateral concaved part 351 is made large to ensure the depth of the groove 35, it will be necessary to thicken the wall thickness from the viewpoint of maintaining strength. In addition, in a case of forming the groove 35 with only the lateral convex part 352, if the projection of the lateral convex part 352 is made large to ensure the depth of the groove 35, the flows of fresh air and EGR gas will be disturbed and pressure loss and turbulence will arise, a result of which the EGR gas cannot be satisfactorily mixed with the fresh air.

In contrast, according to the present embodiment, by forming the groove 35 by combining the lateral concaved part 351 and the lateral convex part 352, it is possible to reduce the wall thickness while ensuring the depth of the groove 35, and it is possible to suppress degradation of the mixing of EGR gas with the fresh air. In addition, since it is possible to adequately ensure the depth of the groove 35, oil, etc. is more reliably led to the intake manifold 6 (combustion chamber) side by flowing inside of the groove 35. Therefore, according to the present embodiment, it is possible to more reliably avoid oil, etc. trickling from the intake pipe 3 side of the merging part 33 and permeating inside of the EGR pipe

4, and it is possible to more reliably avoid the occurrence of operational malfunction of the EGR valve 41 and degradation of the EGR valve 41.

Furthermore, in the present embodiment, by providing the lateral convex part 352 on a lower side of the lateral concaved part 351, the groove top face 353 is formed from the top face of the lateral concaved part 351, and the groove bottom face 354 is formed from the bottom face of the lateral concaved part 351 and the top face of the lateral convex part 352. In addition, in a cross section in a direction orthogonal to the center line X of the intake pipe 3, the length of the groove bottom face 354 is set to be longer than the length of the groove top face 353.

Since oil, etc. flowing inside of the intake pipe 3 flows along the groove bottom face 354, the length of the groove bottom face 354 (i.e. depth of the groove 35) can be ensured to be larger according to the present embodiment. Therefore, according to the present embodiment, it is possible to more reliably avoid oil, etc. trickling from the intake pipe 3 side of the merging part 33 and permeating inside of the EGR pipe 4, and adhering to the EGR valve 41, and it is possible to more reliably avoid the occurrence of operational malfunction of the EGR valve 41 and degradation of the EGR valve 41.

In addition, in the present embodiment, the partition wall 7 dividing and separating the intake pipe 3 and EGR pipe 4 runs along the groove 35 to a downstream side until midway of the groove 35, with the merging part 33 as the starting point.

It is thereby possible to avoid oil, etc. from permeating inside of the EGR pipe 4 by way of the partition wall 7, even in a case of oil, etc. not having flowed from the base end side of the groove 35 to inside of the groove 35. In addition, since the partition wall 7 is only provided along the groove 35 until midway of the groove 35, it is possible to suppress deterioration in the mixing of the EGR gas with the fresh air.

Furthermore, in the present embodiment, the convex part 71 projecting inwards of the intake pipe 3 is provided to a leading end of the partition wall 7. It is thereby possible to suppress oil, etc. flowing inside of the intake pipe 3 from permeating inside of the EGR pipe 4. In particular, since there is no flow of intake air in the intake pipe 3 while the engine 1 is stopped, there is concern over oil, etc. trickling into the EGR pipe 4; however, this can be avoided according to the present embodiment.

In addition, in the present embodiment, the concaved part 72 is provided to a face of the partition wall 7 on a side facing the intake pipe 3. It is thereby possible to more reliably avoid oil, etc. from permeating inside of the EGR pipe 4, since the oil, etc. flowing inside of the intake pipe 3 can be made to stagnate in this concaved part 72. In particular, there is no flow of intake air inside of the intake pipe 3 while the engine 1 is stopped; therefore, there is concern over oil, etc. trickling inside of the EGR pipe 4; however, this can be reliably avoided according to the present embodiment.

In addition, in the present embodiment, the groove 35 and concaved part 72 are connected by joining the concaved part 72 to the side face 31 in which the groove 35 is provided. Since oil, etc. stagnated in the concaved part 72 can thereby be led to the groove 35, oil, etc. can more reliably be avoided from permeating inside of the EGR pipe 4.

Moreover, in the present embodiment, the curved face 38 curving from the concaved part 72 to an upstream side towards the side face 32 is provided between the concaved part 72 and the side face 32, without joining the concaved part 72 to the side face 32 opposing the side face 31 in which the groove 35 is provided. Since the oil, etc. is thereby more reliably led to the concaved part 72 by following the curved face 38, oil, etc. can be more reliably avoided from permeating inside of the EGR pipe 4.

Furthermore, in the present embodiment, the merging part 33 is provided between the compressor and the intake manifold 6 in the intake system 2 of the engine 1 equipped with the compressor and the recirculation means for recirculating blow-by oil to upstream of the compressor. In the case of recirculating blow-by oil to upstream of the compressor in a pressure relationship as in a diesel engine, an abundance of blow-by oil flows inside of the intake pipe 3; therefore, the above-mentioned effect is further raised by providing the groove 35 in the side face 31 of such an intake pipe 3. In addition, since the merging part 33 between the intake pipe 3 and EGR pipe 4 is provided between the compressor and the intake manifold 6 according to the present embodiment, the distance from the merging part 33 to the combustion chamber can be ensured, and the EGR gas can be more satisfactorily mixed with fresh air compared to Patent Document 2.

Furthermore, in the present embodiment, the EGR pipe 4 is made to slope downwards from the EGR valve 41 towards the merging part 33. Since there is no collector of oil, etc. inside of the EGR pipe 4 from the EGR valve 41 to the merging part 33, the oil, etc. can thereby be avoided from collecting inside the EGR pipe 4. In addition, even in a case of oil, etc. trickling from the merging part 33 and permeating inside the EGR pipe 4 while the engine is stopped, for example, the oil, etc. will not flow into the EGR valve 41 due to the EGR pipe 4 from the EGR valve 41 to the merging part 33 being a hanging structure sloped downwards. Therefore, according to the present embodiment, oil, etc. can more reliably be avoided from adhering to the EGR valve 41, and thus the occurrence of operational malfunction of the EGR valve 41 and degradation of the EGR valve 41 can be more reliably avoided.

It should be noted that the present invention is not to be limited to the above-mentioned embodiment, and that modifications, improvements, etc. within a scope that can achieve the object of the present invention are also included in the present invention.

For example, although the groove 35 is provided with the junction 34, which is a junction between the merging part 33 and the side face 31, as a starting point in the above-mentioned embodiment, the groove 35 may be provided from a side further upstream than the junction 34 so as to pass through this junction 34.

Furthermore, although the concaved part 72 is provided above the partition wall 7 in the above-mentioned embodiment, it may be provided to run further to an upstream side and extend until above the bottom face 36 of the intake pipe 3. It thereby comes to be possible to further stagnate oil, etc., and thus oil, etc. can be more reliably avoided from trickling from the intake pipe 3 side of the merging part 33 and permeating inside the EGR pipe 4. In addition, since the partition wall 7 is run to a downstream side, there is a limitation in manufacturing; however, by providing the concaved part 72 to extend until above the bottom face 36 of the intake pipe 3, this limitation can be relaxed, and the running length of the partition wall 7 is easily ensured.