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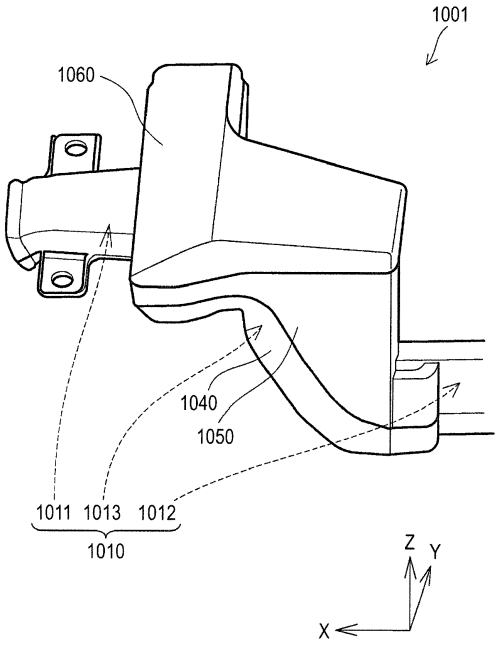
(54) AIR INTAKE DEVICE OF INTERNAL COMBUSTION ENGINE

(57) An air intake device of an internal combustion engine includes: a first resonator and a second resonator which have a first volume chamber and a second volume chamber, respectively, the first and second volume chambers communicating with an intake air flow passage feeding air to the internal combustion engine; and a first member, a second member and a third member which form the first resonator and the second resonator. The first resonator is formed by the first member and the second member; and the second resonator is formed by the second member and the third member.

FIG. 1



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Description

BACKGROUND

[0001] The present invention relates to an air intake device of an internal combustion engine, in which a resonator is provided in an air intake pipe so as to suppress resonance sound of an intake system.

[0002] There are air intake pipes of internal combustion engines, which are provided with resonators for suppressing resonance sounds of the air intake pipes (e.g. see Japanese Patent No. 3923198 and JP-A-9-112365). Such a resonator has a substantially equal width to an air intake pipe and is formed on a lower face side of the air intake pipe. The position or capacity of the resonator connected to the air intake pipe can be adjusted suitably in order to adjust a frequency of intake noise to be attenuated.

[0003] For example, for absorbing low-frequency intake noise, it is necessary to increase the volume of the resonator. In such a case, it is necessary to enlarge the resonator disclosed in Japanese Patent No. 3923198 either in a width direction or further in a down direction. However, the position or capacity of the resonator is restricted by the layout of various devices such as an internal combustion engine, the air intake pipe, and an air cleaner disposed on the air intake pipe. That is, when the volume of the resonator is changed to absorb intake noise at a specific frequency, the resonator may be increased in size to interfere with the various devices.

SUMMARY

[0004] In consideration of the aforementioned situation, an object of the invention is to provide an air intake device of an internal combustion engine which is compact and which is provided with resonators capable of attenuating intake noises at desired frequencies respectively.

[0005] Further, another object of the invention is to provide an air intake device of an internal combustion engine which is hardly restricted by various devices such as an air intake pipe and which is provided with a resonator attenuating intake noise at a desired frequency.

[0006] According to the first aspect of the invention, there is provided an air intake device of an internal combustion engine, the air intake device comprising: a first resonator and a second resonator which have a first volume chamber and a second volume chamber, respectively, the first and second volume chambers communicating with an intake air flow passage feeding air to the internal combustion engine; and a first member, a second member and a third member which form the first resonator and the second resonator, characterized in that: the first resonator is formed by the first member and the second member; and the second resonator is formed by the second member and the third member.

[0007] In the first aspect, the two, first and second resonators can be disposed to overlap with each other in plan view. In other words, an area occupied by the air intake device within a plane can be reduced, in comparison with a case where the first resonator and the second resonator are disposed not to overlap with each other in plan view. Thus, the air intake device can be configured compactly without increasing its size. When the volumes of the volume chambers of the two, first and second resonators are set suitably, intake noises at desired frequencies can be attenuated. According to the invention in this aspect, it is possible to provide an air intake device of an internal combustion engine which is compact and which is provided with a first resonator and a second resonator capable of attenuating intake noises at desired frequencies respectively.

[0008] According to the second aspect of the invention, in the air intake device of the first aspect, volume of the first volume chamber is different from volume of the second volume chamber.

[0009] In the second aspect, when the first resonator and the second resonator having their volume chambers with different volumes are used together, it is possible to attenuate intake noises at different frequency bands.

[0010] According to the third aspect of the invention, in the air intake device of the first or second aspect, the intake air flow passage is formed by the second member and the third member, or the intake air flow passage is formed by the first member and the second member.

[0011] In the third aspect, the air intake device can be made more compact, in comparison with a case where the intake air flow passage is not formed by the first member, the second member and the third member.

[0012] According to the fourth aspect of the invention, in the air intake device of the third aspect, the first resonator is formed on one side of the intake air flow passage in plan view; and the second resonator is formed to overlap with the intake air flow passage and extend to both sides of the intake air flow passage in plan view.

[0013] In the fourth aspect, an area which is occupied by the intake air flow passage and the second resonator within a plane can be reduced, in comparison with a case where the intake air flow passage and the second resonator are disposed not to overlap with each other in plan view. Thus, the air intake device can be formed to have a more compact size.

[0014] According to the fifth aspect of the invention, in the air intake device of any one of the third to fifth aspect, the first resonator is provided with a first communication pipe which branches from the intake air flow passage to communicate with the first volume chamber; the second resonator is provided with a second communication pipe which branches from the intake air flow passage to communicate with the second volume chamber; and at least one of the first communication pipe and the second communication pipe is provided to extend in a direction along an air flow of the intake air flow passage.

[0015] In the fifth aspect, even when the second communication pipe is made long, the second communication pipe can be kept compact without easily interfering with

any other device. In addition, the length of the second communication pipe can be increased to attenuate intake noise at a low frequency.

[0016] According to the sixth aspect of the invention, in the air intake device of the fifth aspect, length of the first communication pipe is different from length of the second communication pipe.

[0017] In the sixth aspect, when the first communication pipe and the second communication pipe having different lengths from each other are used together, intake noises at different frequency bands can be attenuated.

[0018] According to the seventh aspect of the invention, in the air intake device of the fifth or sixth aspect, the intake air flow passage is formed by the first member and the second member to be inclined downward from an upstream side toward a downstream side; the first volume chamber is formed on one side of the intake air flow passage in plan view; the second volume chamber is formed to overlap with the intake air flow passage and extend to both sides of the intake air flow passage in plan view; the second communication pipe is provided to extend in the direction along the air flow of the intake air flow passage; and an outlet of the second communication pipe connected to the second volume chamber is positioned on an upper side than an inlet of the second communication pipe connected to the intake air flow passage.

[0019] In the seventh aspect, water can be prevented from entering the second resonator through the second communication pipe so that the volume of the volume chamber of the second resonator can be prevented from varying due to the water. Thus, an intake noise attenuation effect achieved by the second resonator can be maintained excellent.

[0020] According to the eighth aspect of the invention, there is provided an air intake device of an internal combustion engine, the air intake device comprising: an intake air flow passage which is a flow passage of air to be fed to the internal combustion engine; and a resonator which includes a communication pipe communicating with the intake air flow passage, and a volume chamber communicating with the intake air flow passage through the communication pipe, characterized in that the communication pipe is provided to extend along the intake air flow passage.

[0021] In the eighth aspect, the communication pipe can be configured to have a length or diameter suitable for attenuation of resonance sound at a desired frequency after the volume chamber has been disposed in accordance with the layout of various devices such as the internal combustion engine, the intake air flow passage, and an air cleaner disposed on the intake air flow passage. Accordingly, the air intake device can attenuate resonance sound at a desired frequency without being easily restricted by the layout etc. of the various devices such as the intake air flow passage. In addition, the communication pipe is provided to extend along the intake air flow passage. Therefore, a required space for the communication pipe is only around the intake air flow passage so that space saving can be achieved.

[0022] According to the ninth aspect of the invention, in the air intake device of the eighth aspect, a direction of an air flow in the communication pipe is opposite to a direction of an air flow in the intake air flow passage.

[0023] In the ninth aspect, water can be prevented from being accumulated in the volume chamber through the communication pipe so that the volume of the volume chamber can be suppressed from varying. Thus, a resonance sound attenuation effect achieved by the volume chamber can be maintained excellently.

[0024] According the tenth aspect of the invention, in the air intake device of the eighth or ninth aspect, an inlet of the communication pipe which is an opening on a side of the intake air flow passage faces down.

[0025] In the tenth aspect, moisture can be more surely prevented from entering the communication pipe.

[0026] According to the eleventh aspect of the invention, in the air intake device of any one of the eighth to tenth aspect, the intake air flow passage is inclined downward from an upstream side toward a downstream side; and an outlet of the communication pipe which is an opening on a side of the volume chamber is positioned on an upper side than an inlet of the communication pipe which is an opening on a side of the intake air flow passage.

[0027] In the eleventh aspect, moisture can be more surely prevented from entering the communication pipe.

[0028] According to the twelfth aspect of the invention, in the air intake device of the eleventh aspect, the intake air flow passage includes an inclined intake air flow passage which is inclined downward from the upstream side toward the downstream side; and the volume chamber is formed to overlap with the inclined intake air flow passage in side view.

[0029] In the twelfth aspect, a space occupied by the volume chamber can be reduced in a height direction.

[0030] According to the thirteenth aspect of the invention, in the air intake device of any one of the eighth to twelfth aspect, a first member, a second member and a third member which are superimposed on one another to be formed integrally to thereby form the intake air flow passage, the communication pipe and the volume chamber are provided; the first member includes a first intake air flow passage forming part forming a part of the intake air flow passage on a side of the second member, and a first communication pipe forming part forming a part of the communication pipe on a side of the second member; the second member includes a second intake air flow passage forming part forming a part of the intake air flow passage on a side of the first member, a second communication pipe forming part forming a part of the communication pipe on a side of the first member, and a first volume chamber forming part forming a part of the volume chamber on a side of the third member; the third member includes a second volume chamber forming part forming a part of the volume chamber on a side of the second member; the intake air flow passage is formed out of the first intake air flow passage forming part and

the second intake air flow passage forming part; the communication pipe is formed out of the first communication pipe forming part and the second communication pipe forming part; and the volume chamber communicating with the communication pipe is formed out of the first volume chamber forming part and the second volume chamber forming part.

[0031] In the thirteenth aspect, the intake air flow passage, the volume chamber and the communication pipe can be formed integrally by the first member, the second member and the third member, so that the components can be arranged compactly. In addition, when the first member, the second member and the third member are formed suitably, the length of the communication pipe can be adjusted desirably. Thus, when only a small number of components are changed, an air intake device provided with a resonator for attenuating resonance sound at a desired frequency can be configured.

[0032] According to the fourteenth aspect of the invention, in the air intake device of any one of the eighth to twelfth aspect, a first member, a second member and a third member which are superimposed on one another to be formed integrally to thereby form the intake air flow passage, a housing chamber for housing the communication pipe, and the volume chamber are provided; the first member includes a first intake air flow passage forming part forming a part of the intake air flow passage on a side of the second member, and the volume chamber opened to a side of the second member; the second member includes a second intake air flow passage forming part forming a part of the intake air flow passage on a side of the first member, and a first housing chamber forming part forming a part of the housing chamber on a side of the third member; the third member includes a second housing chamber forming part forming a part of the housing chamber on a side of the second member; the intake air flow passage is formed out of the first intake air flow passage forming part and the second intake air flow passage forming part; the housing chamber is formed out of the first housing chamber forming part and the second housing chamber forming part; the volume chamber and the housing chamber communicate with each other; and the communication pipe is housed in the housing chamber, and the housing chamber and the intake air flow passage communicate with each other through the communication pipe.

[0033] In the fourteenth aspect, the intake air flow passage and the volume chamber can be formed integrally, so that the components can be arranged compactly. In addition, when only the communication pipe is replaced by another one with a different length or diameter, an air intake device provided with a resonator for attenuating resonance sound at a desired frequency can be configured.

[0034] According to the invention, it is possible to provide an air intake device of an internal combustion engine which is compact and which is provided with resonators capable of attenuating resonance sounds at desired frequencies respectively.

[0035] According to the invention, it is possible to provide an air intake device of an internal combustion engine which is hardly restricted by various devices such as an air intake pipe, and which is provided with a resonator attenuating resonance sound at a desired frequency.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036]

Fig. 1 is a perspective view showing an external appearance of an air intake device according to Embodiment 1.
Fig. 2 is an exploded perspective view of the air intake device according to Embodiment 1.
Fig. 3 is a plan view of the air intake device according to Embodiment 1.
Fig. 4 is a sectional view taken along a line A-A of Fig. 3.
Fig. 5 is a sectional view taken along a line B-B of Fig. 3.
Fig. 6 is a sectional view taken along a line C-C of Fig. 3.
Fig. 7 is a sectional view taken along a line D-D of Fig. 3.
Fig. 8 is a plan view of the air intake device showing an air flow.
Fig. 9 is a perspective view showing an external appearance of an air intake device according to Embodiment 2.
Fig. 10 is an exploded perspective view of the air intake device according to Embodiment 2.
Fig. 11 is a plan view of the air intake device according to Embodiment 2.
Fig. 12 is a sectional view taken along a line A-A of Fig. 11.
Fig. 13 is a sectional view taken along a line B-B of Fig. 11.
Fig. 14 is a sectional view taken along a line C-C of Fig. 11.
Fig. 15 is a plan view of the air intake device showing an air flow according to Embodiment 2.
Fig. 16 is a plan view showing an external appearance of an air intake device according to Embodiment 3.
Fig. 17 is a side view of the air intake device according to Embodiment 3.
Fig. 18 is a perspective view of the air intake device according to Embodiment 3.
Fig. 19 is a sectional view taken along a line D-D of Fig. 16.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0037] Embodiments of the invention will be described below. Incidentally, the embodiments will be described

by way of example. Therefore, the invention is not limited to the following description.

(Embodiment 1)

[0038] An air intake device of an internal combustion engine according to Embodiment 1 will be described with reference to Fig. 1 to 7. Fig. 1 is a perspective view showing an external appearance of the air intake device. Fig. 2 is an exploded perspective view of the air intake device. Fig. 3 is a plan view of the air intake device. Fig. 4 is a sectional view taken along a line A-A of Fig. 3. Fig. 5 is a sectional view taken along a line B-B of Fig. 3. Fig. 6 is a sectional view taken along a line C-C of Fig. 3. Fig. 7 is a sectional view taken along a line D-D of Fig. 3. A third member is not shown in the plan view of Fig. 3. The section taken along the line A-A is a section which passes through a first resonator 1020, a second resonator 1030, an intake air flow passage 1010, and a second outlet 1121. The section taken along the line B-B is a section which passes through the first resonator 1020, the second resonator 1030, a first communication pipe 1091, the intake air flow passage 1010, and the second outlet 1121. The section taken along the line C-C is a section which passes through the second resonator 1030, the intake air flow passage 1010, and a second communication pipe 1092. The section taken along the line D-D is a section which passes through the second resonator 1030, the intake air flow passage 1010, and a second inlet 1120. In addition, an X direction indicates a front/rear direction of a car; a Y direction, a vehicle width direction of the car; and a Z direction, a height direction of the car.

[0039] The air intake device 1001 of the internal combustion engine according to Embodiment 1 is provided with the first resonator 1020, the second resonator 1030, and a first member 1040, a second member 1050 and a third member 1060 which form the first resonator 1020 and the second resonator 1030.

[0040] The air intake device 1001 according to Embodiment 1 is provided with the intake air flow passage 1010. The intake air flow passage 1010 is a flow passage of air to be fed to the internal combustion engine (not shown). The intake air flow passage 1010 according to Embodiment 1 is constituted by an upstream intake air flow passage 1011, a downstream intake air flow passage 1012, and an inclined intake air flow passage 1013 provided between the upstream intake air flow passage 1011 and the downstream intake air flow passage 1012.

[0041] The upstream intake air flow passage 1011 is a flow passage which has an air intake port (not shown) for taking in air at its one end side and which extends rearward (rearward in the X direction). The inclined intake air flow passage 1013 is a flow passage which continues from the upstream intake air flow passage 1011 and is then inclined downward toward the rear. The downstream intake air flow passage 1012 is a flow passage which continues from the inclined intake air flow passage 1013 and then extends rearward. A rear side of the downstream intake air flow passage 1012 is connected to the not-shown internal combustion engine. Incidentally, a device such as an air cleaner may be provided on an upstream side of the internal combustion engine on the downstream side of the downstream intake air flow passage 1012.

[0042] The first resonator 1020 is provided with a first volume chamber 1081 and the first communication pipe 1091. The first volume chamber 1081 is a space part having a predetermined volume. Similarly, the second resonator 1030 is provided with a second volume chamber 1082 and the second communication pipe 1092. The second volume chamber 1082 is a space part having a predetermined volume. The first resonator 1020 is formed by the first member 1040 and the second member 1050. The second resonator 1030 is formed by the second member 1050 and the third member 1060. Specifically, the first member 1040, the second member 1050 and the third member 1060 are connected to one another in the named order from bottom in a vertical direction (Z direction). That is, the first member 1040 is connected to a lower face side of the second member 1050, and the third member 1060 is connected to an upper face side of the second member 1050. For example, the first member 1040, the second member 1050 and the third member 1060 are molded out of a resin. However, the material of the first member 1040, the second member 1050 and the third member 1060 is not limited particularly.

[0043] The first communication pipe 1091 of the first resonator 1020 is a flow passage which branches from the intake air flow passage 1010 to communicate with the first volume chamber 1081. The second communication pipe 1092 of the second resonator 1030 is a flow passage which branches from the intake air flow passage 1010 to communicate with the second volume chamber 1082. The first communication pipe 1091 and the second communication pipe 1092 are also formed by the first member 1040, the second member 1050 and the third member 1060.

[0044] The first member 1040 is a member which is connected to the second member 1050, and which forms the first resonator 1020 together with the second member 1050. In addition, in Embodiment 1, the first member 1040 is a member which forms the intake air flow passage 1010 together with the second member 1050.

[0045] Specifically, a lower-side intake air flow passage forming part 1041 which forms a part of the intake air flow passage 1010 is provided in the first member 1040. The lower-side intake air flow passage forming part 1041 is formed into a groove shape which is recessed in section and which is opened to the second member 1050 side. In addition, portions of the lower-side intake air flow passage forming part 1041 which serve as the upstream intake air flow passage 1011 and the downstream intake air flow passage 1012 are substantially horizontal. A portion of the lower-side intake air flow passage forming part 1041 which serves as the inclined intake air flow passage 1013 is inclined downward toward the downstream side.

[0046] A lower-side first communication pipe forming part 1042 which forms a part of the first communication pipe 1091 is provided in the first member 1040. The lower-side first communication pipe forming part 1042 is formed into a groove shape which is recessed in section and which is opened to the second member 1050 side. Through the lower-side first communication pipe forming part 1042, the portion of the lower-side intake air flow passage forming part 1041 which serves as the inclined intake air flow passage 1013, and a lower-side first volume chamber forming part 1043 which will be described below are made to communicate with each other. An opening portion of the lower-side first communication pipe forming part 1042 which forms a boundary with the lower-side intake air flow passage forming part 1041 is referred to as lower-side first inlet 1047. An opening portion of the lower-side first communication pipe forming part 1042 which forms a boundary with the lower-side first volume chamber forming part 1043 is referred to as lower-side first outlet 1048.

[0047] The lower-side first volume chamber forming part 1043 which forms a part of the first volume chamber 1081 is provided in the first member 1040. The lower-side first volume chamber forming part 1043 is formed into a groove shape which is substantially rectangular in plan view and which is recessed in section. The lower-side first volume chamber forming part 1043 communicates with the lower-side first communication pipe forming part 1042.

[0048] A lower-side second communication pipe forming part 1044 which forms a part of the second communication pipe 1092 is provided in the first member 1040. The lower-side second communication pipe forming part 1044 is formed into a groove shape which is recessed in section and which is opened to the second member 1050 side. In addition, the lower-side second communication pipe forming part 1044 is provided to extend along the lower-side intake air flow passage forming part 1041. The lower-side second communication pipe forming part 1044 is inclined downward from the front toward the rear in the vehicle front/rear direction.

[0049] The lower-side intake air flow passage forming part 1041 and the lower-side second communication pipe forming part 1044 are separated from each other by a wall part 1045. In addition, a portion of the wall part 1045 is notched so that a lower-side second inlet 1046 is formed therein. Through the lower-side second inlet 1046, one downstream-side end portion of the lower-side intake air flow passage forming part 1041 and one downstream-side end portion of the lower-side second communication pipe forming part 1044 communicate with each other.

[0050] The second member 1050 is a member which is connected to the first member 1040 and the third member 1060, and which forms the first resonator 1020 together with the first member 1040 and forms the second resonator 1030 together with the third member 1060. In addition, in Embodiment 1, the second member 1050 is a member which forms the intake air flow passage 1010 together with the first member 1040.

[0051] An upper-side intake air flow passage forming part 1051 which forms a part of the intake air flow passage 1010 is provided in the second member 1050. The upper-side intake air flow passage forming part 1051 is formed into a groove shape which is recessed in section and which is opened to the first member 1040 side. In addition, the upper-side intake air flow passage forming part 1051 is inclined downward from the front toward the rear in the vehicle front/rear direction in line with the inclination of the lower-side intake air flow passage forming part 1041.

[0052] An upper-side first communication pipe forming part 1052 which forms a part of the first communication pipe 1091 is provided in the second member 1050. The upper-side first communication pipe forming part 1052 is formed into a groove shape which is recessed in section and which is opened to the first member 1040 side. Through the upper-side first communication pipe forming part 1052, the inclined intake air flow passage 1013 of the intake air flow passage 1010 and an upper-side first volume chamber forming part 1053 which will be described below are made to communicate with each other. An opening portion of the upper-side first communication pipe forming part 1052 which forms a boundary with the upper-side intake air flow passage forming part 1051 is referred to as upper-side first inlet 1058. An opening portion of the upper-side first communication pipe forming part 1052 which forms a boundary with the upper-side first volume chamber forming part 1053 is referred to as upper-side first outlet 1059.

[0053] The upper-side first volume chamber forming part 1053 which forms a part of the first volume chamber 1081 is provided in the second member 1050. Although not shown particularly, the upper-side first volume chamber forming part 1053 is formed into a groove shape which is substantially rectangular in plan view (in plan view when the second member 1050 is seen from the first member 1040 side) and which is recessed in section. The upper-side first volume chamber forming part 1053 communicates with the upper-side first communication pipe forming part 1052.

[0054] An upper-side second communication pipe forming part 1054 which forms a part of the second communication pipe 1092 is provided in the second member 1050. The upper-side second communication pipe forming part 1054 is formed into a groove shape which is recessed in section and which is opened to the first member 1040 side. In addition, the upper-side second communication pipe forming part 1054 is provided to extend along the lower-side intake air flow passage forming part 1041. The upper-side second communication pipe forming part 1054 is inclined downward from the front toward the rear in the vehicle front/rear direction.

[0055] The upper-side intake air flow passage forming part 1051 and the upper-side second communication pipe forming part 1054 are separated from each other by

a wall part 1055. In addition, a portion of the wall part 1055 is notched so that an upper-side second inlet 1056 is formed therein. Through the upper-side second inlet 1056, one downstream-side end portion of the upper-side intake air flow passage forming part 1051 and one downstream-side end portion of the upper-side second communication pipe forming part 1054 communicate with each other.

[0056] A lower-side second volume chamber forming part 1057 forming a part of the second volume chamber 1082 is provided in the second member 1050. In Embodiment 1, a wall part 1150 is provided on an upper face side (a face on the third member 1060 side) of the second member 1050. An internal region of the wall part 1150 is the lower-side second volume chamber forming part 1057. The wall part 1150 is formed to surround the first resonator 1020, the inclined intake air flow passage 1013 of the intake air flow passage 1010, the second outlet 1121 and an inclined part of the second communication pipe 1092 in plan view.

[0057] The second outlet 1121 communicating with one upstream-side end portion of the upper-side second communication pipe forming part 1054 is provided in the second member 1050. The second outlet 1121 is a hole which penetrates the second member 1050 in the thickness direction and through which the upper-side second communication pipe forming part 1054 and the lower-side second volume chamber forming part 1057 are made to communicate with each other. In addition, the second outlet 1121 faces toward a central side of the lower-side second volume chamber forming part 1057. Thus, air coming out from the second outlet 1121 is controlled to flow toward a central side of the second volume chamber 1082. In this manner, air flows in toward the central side of the second volume chamber 1082. Accordingly, an intake noise attenuation effect can be obtained easily.

[0058] The third member 1060 is a member which is connected to the second member 1050, and which forms the second resonator 1030 together with the second member 1050.

[0059] An upper-side second volume chamber forming part 1061 which forms a part of the second volume chamber 1082 is provided in the third member 1060. The upper-side second volume chamber forming part 1061 is formed into a grove shape which is recessed in section and which is opened to have substantially the same shape as that of the lower-side second volume chamber forming part 1057.

[0060] When the first member 1040, the second member 1050 and the third member 1060 are connected integrally with one another, the air intake device 1001 having the intake air flow passage 1010, the first resonator 1020 and the second resonator 1030 is formed.

[0061] That is, one intake air flow passage 1010 in which the opening of the lower-side intake air flow passage forming part 1041 and the opening of the upper-side intake air flow passage forming part 1051 are connected to each other is formed by the first member 1040 and the second member 1050.

[0062] In addition, one first communication pipe 1091 in which the opening of the lower-side first communication pipe forming part 1042 and the opening of the upper-side first communication pipe forming part 1052 are connected to each other is formed by the first member 1040 and the second member 1050. Further, one first volume chamber 1081 in which the opening of the lower-side first volume chamber forming part 1043 and the opening of the upper-side first volume chamber forming part 1053 are connected to each other is formed by the first member 1040 and the second member 1050. The first resonator 1020 provided with the first volume chamber 1081 and the first communication pipe 1091 is formed.

[0063] In addition, one second communication pipe 1092 in which the opening of the lower-side second communication pipe forming part 1044 and the opening of the upper-side second communication pipe forming part 1054 are connected to each other is formed by the first member 1040 and the second member 1050. Further, one second volume chamber 1082 in which the opening of the lower-side second volume chamber forming part 1057 and the opening of the upper-side second volume chamber forming part 1061 are connected to each other is formed by the second member 1050 and the third member 1060. The second resonator 1030 provided with the second volume chamber 1082 and the second communication pipe 1092 is formed.

[0064] In addition, when the first member 1040 and the second member 1050 are connected to each other, a first inlet 1110, a first outlet 1111, and the second inlet 1120 are formed. That is, one first inlet 1110 is formed by the lower-side first inlet 1047 and the upper-side first inlet 1058. One first outlet 1111 is formed by the lower-side first outlet 1048 and the upper-side first outlet 1059. One second inlet 1120 is formed by the lower-side second inlet 1046 and the upper-side second inlet 1056.

[0065] A part of the second member 1050 to which the third member 1060 is connected is a top face 1151 of the wall part 1150 which forms the lower-side second volume chamber forming part 1057. The top face 1151 is an approximately horizontal face facing the third member 1060 side. On the other hand, although not shown particularly, a part of the third member 1060 to which the second member 1050 is connected is also an approximately horizontal flat face which has the same shape as the top face 1151 and which faces the second member 1050 side.

[0066] Thus, the second member 1050 and the third member 1060 are connected to each other at their horizontal faces. Therefore, a gap is hardly generated between the second member 1050 and the third member 1060. Thus, airtightness of the second volume chamber 1082 formed by the second member 1050 and the third member 1060 can be improved.

[0067] In Embodiment 1, the intake air flow passage 1010 has the inclined intake air flow passage 1013 which

is inclined. In order to form the inclined intake air flow passage 1013, the upper-side intake air flow passage forming part 1051 of the second member 1050 is inclined. Thus, although the second member 1050 includes the inclined part, the face where the second member 1050 is connected to the third member 1060 can be formed as a horizontal face due to the provision of the wall part 1150.

[0068] As shown in Fig. 4, an upper part of the first volume chamber 1081 protrudes inside the second volume chamber 1082. Specifically, the upper-side first volume chamber forming part 1053 constituting the first volume chamber 1081 protrudes more closely to the third member 1060 than the top face 1151 of the wall part 1150.

[0069] Since the first volume chamber 1081 protrudes inside the second volume chamber 1082 in this manner, the volume of the first volume chamber 1081 can be made larger. That is, in order to enlarge the first volume chamber 1081, the first volume chamber 1081 does not have to be enlarged in the X direction and the Y direction. It will go well only if the first volume chamber 1081 is enlarged in the Z direction. Thus, the size occupied by the first volume chamber 1081 within the XY plane can be reduced.

[0070] In addition, since the first volume chamber 1081 does not have to be enlarged within the XY plane, the first volume chamber 1081 can be formed into a simple shape such as an approximately rectangular parallelepiped shape (an approximately quadrangular shape as a shape in plan view) as in Embodiment 1. When the first volume chamber 1081 is formed into a rectangular parallelepiped shape, air discharged from the first outlet 1111 of the first communication pipe 1091 can be sent out toward a central portion of the first volume chamber 1081. Thus, the air can be diffused evenly and rapidly from the first communication pipe 1091 into the first volume chamber 1081 so that a desired frequency of intake noise can be attenuated easily.

[0071] When the first volume chamber 1081 is enlarged within the XY plane, a plurality of small chambers may have no choice but to be connected to be one volume chamber. For example, such a volume chamber may have an L-shape or a U-shape in plan view, and may have a configuration in which depth differs from one small chamber to another. In the volume chamber shaped thus, air may be diffused unevenly. Thus, it may be difficult to attenuate the desired frequency. On the other hand, according to Embodiment 1, the first volume chamber 1081 has a single rectangular parallelepiped shape as if volumes of such small chambers were put into one in the height direction. Therefore, the first volume chamber 1081 can be formed into a shape which can diffuse air evenly and rapidly in spite of its volume equal to the volume chamber in which the small chambers have been connected to one another. Thus, the first volume chamber 1081 can attenuate the desired frequency.

[0072] As described above, in the air intake device 1001, the first resonator 1020 is formed by the first member 1040 and the second member 1050, and the second resonator 1030 is formed by the second member 1050 and the third member 1060. The first volume chamber 1081 of the first resonator 1020 communicates with the intake air flow passage 1010 through the first communication pipe 1091. The second volume chamber 1082 of the second resonator 1030 communicates with the intake air flow passage 1010 through the second communication pipe 1092.

[0073] An air flow in the air intake device 1001 having such a configuration will be described with reference to Fig. 8 etc. Fig. 8 is a plan view of the air intake device showing the air flow. Incidentally, the first member is not shown in Fig. 8.

[0074] As indicated by an arrow L in Fig. 8, external air flows into the intake air flow passage 1010 to be sent out to the internal combustion engine from the downstream intake air flow passage 1012 (see Fig. 1). As indicated by an arrow M in Fig. 5 and Fig. 8, a part of the air flowing into the intake air flow passage 1010 flows into the first communication pipe 1091 to reach the first volume chamber 1081. Further, as shown in an arrow N in Fig. 4, Fig. 5, Fig. 7 and Fig. 8, a part of the air flowing into the intake air flow passage 1010 flows into the second communication pipe 1092 to reach the second volume chamber 1082.

[0075] In the air intake device 1001 of the internal combustion engine having the aforementioned configuration, the two, first and second resonators 1020 and 1030 are provided when the first member 1040, the second member 1050 and the third member 1060 are connected integrally with one another. With such a configuration, the two, first and second resonators 1020 and 1030 can be disposed to overlap with each other in plan view, as shown in Fig. 8. In other words, the area occupied by the air intake device 1001 within a plane can be reduced, in comparison with a case where the first resonator 1020 and the second resonator 1030 are disposed not to overlap with each other in plan view. The two, first and second resonators 1020 and 1030 can be accommodated within a region which corresponds to substantially one second resonator 1030 in plan view.

[0076] Thus, the air intake device 1001 can be configured compactly without increasing its size. Since the volumes of the two, first and second resonators 102 and 1030 are set suitably, intake noises having desired frequencies can be attenuated. Thus, according to the invention, it is possible to provide the air intake device 1001 of the internal combustion engine which is compact and which is provided with the first resonator 1020 and the second resonator 1030 having volumes to attenuate the desired frequencies.

[0077] In the air intake device 1001 according to Embodiment 1, the first volume chamber 1081 of the first resonator 1020 and the second volume chamber 1082 of the second resonator 1030 are different from each other in volume. In Embodiment 1, the volume of the first volume chamber 1081 is smaller than the volume of the second volume chamber 1082. According to Helmholtz's

laws, high-frequency intake noise is attenuated as the volume of a volume chamber is reduced, and low-frequency intake noise is attenuated as the volume of the volume chamber is increased. Accordingly, high-frequency intake noise can be attenuated by the first volume chamber 1081 which is relatively small in volume and low-frequency intake noise can be attenuated by the second volume chamber 1082 which is relatively large in volume.

[0078] When the first volume chamber 1081 and the second volume chamber 1082 having different volumes are used together in this manner, intake noises having different frequency bands can be attenuated.

[0079] In the air intake device 1001 according to Embodiment 1, the intake air flow passage 1010, together with the first resonator 1020 and the second resonator 1030, is formed by the first member 1040, the second member 1050 and the third member 1060. Thus, the air intake device 1001 can be made more compact, in comparison with a case where the intake air flow passage 1010 is not formed in the first member 1040, the second member 1050 and the third member 1060.

[0080] When the intake air flow passage 1010 is not formed in the first member 1040, the second member 1050 and the third member 1060, pipe-like members (members corresponding to the first communication pipe 1091 and the second communication pipe 1092) for connection between the intake air flow passage 1010 and the first member 1040, the second member 1050 and the third member 1060 have to be provided separately. In this case, the number of components increases, and a space for disposing the components is required to thereby lead to a slight increase in the size. Incidentally, an air intake device in which the intake air flow passage 1010 is not formed in the first member 1040, the second member 1050 and the third member 1060 is included in the invention described in Claims.

[0081] In the air intake device 1001 according to Embodiment 1, the intake air flow passage 1010 and the first resonator 1020 are formed by the first member 1040 and the second member 1050. Specifically, in the plan view shown in Fig. 3, the first volume chamber 1081 of the first resonator 1020 is formed on one side (one side in the Y direction) of the intake air flow passage 1010. In the plan view shown in Fig. 3, the second volume chamber 1082 of the second resonator 1030 formed by the second member 1050 and the third member 1060 is formed to overlap with the intake air flow passage 1010 and extend to both sides (both sides in the Y direction) of the intake air flow passage 1010. That is, the layout including the intake air flow passage 1010 and the first volume chamber 1081 of the first resonator 1020 is located within the region occupied by the second resonator 1030 in plan view.

[0082] According to the air intake device 1001 having such a configuration, the area occupied by the air intake device 1001 within a plane can be reduced, in comparison with a case where the intake air flow passage 1010 and the second volume chamber 1082 are disposed not to overlap with each other in plan view. Thus, the air intake device 1001 can be disposed with a more compact size and around the intake air flow passage 1010 so that the air intake device 1001 can be prevented more greatly from interfering with various devices mounted in the car. Accordingly, the upper limits of the volumes of the two, first and second resonators 1020 and 1030 can be made larger so that the first and second resonators 1020 and 1030 can flexibly cope with frequencies of intake noises to be attenuated.

[0083] In the air intake device 1001 according to Embodiment 1, the second communication pipe 1092 extends in the direction (the X direction) along the air flow in the intake air flow passage 1010. Therefore, a required space for the second communication pipe 1092 is only around the intake air flow passage 1010. Since a space where the intake air flow passage 1010 should be disposed is originally provided in a vehicle, there is little fear that the space required for forming the second communication pipe 1092 may interfere with any other device. That is, the second communication pipe 1092 can be made longer without interfering with any other device.

[0084] Here, according to the Helmholtz's laws, as the second communication pipe 1092 is increased in length, low-frequency intake noise can be attenuated. Accordingly, even when the second communication pipe 1092 is increased in length, it can be kept compact without easily interfering with any other device. In addition, the second communication pipe 1092 can be formed to be longer to effectively attenuate low-frequency intake noise.

[0085] Further, the first volume chamber 1081 of the first resonator 1020 or the second volume chamber 1082 of the second resonator 1030 and the intake air flow passage 1010 are connected not directly but indirectly through the first communication pipe 1091 or the second communication pipe 1092 respectively. Thus, when only the lengths or diameters of the first communication pipe 1091 and the second communication pipe 1092 are adjusted suitably, frequencies of intake noises which can be attenuated in the first volume chamber 1081 and the second volume chamber 1082 can be set as desired frequencies.

[0086] In the air intake device 1001 according to Embodiment 1, the length of the first communication pipe 1091 is different from the length of the second communication pipe 1092. Specifically, the length of the first communication pipe 1091 is shorter than the length of the second communication pipe 1092.

[0087] As describe above, according to the Helmholtz's laws, when the first communication pipe 1091 and the second communication pipe 1092 are increased in length, low-frequency intake noise can be attenuated. When the first communication pipe 1091 and the second communication pipe 1092 are reduced in length, high-frequency intake noise can be attenuated.

[0088] Accordingly, high-frequency intake noise can

be attenuated by the relatively short first communication pipe 1091 while low-frequency intake noise can be attenuated by the relatively long second communication pipe 1092. When the first communication pipe 1091 and the second communication pipe 1092 having different lengths from each other are used together, intake noises having different frequency bands can be attenuated.

[0089] Particularly, in Embodiment 1, the first volume chamber 1081 connected to the first communication pipe 1091 has a volume to attenuate high-frequency intake noise, and the second volume chamber 1082 connected to the second communication pipe 1092 has a volume to attenuate low-frequency intake noise. That is, the first communication pipe 1091 and the first volume chamber 1081 have configurations suitable for attenuation of the high-frequency intake noise. The second communication pipe 1092 and the second volume chamber 1082 have configurations suitable for attenuation of the low-frequency intake noise.

[0090] In order to attenuate intake noise at a desired frequency, the volume of the volume chamber or the layout of the resonator with respect to the intake air flow passage 1010 has to be changed in the background art. On the other hand, in the air intake device 1001 according to Embodiment 1, the first communication pipe 1091 and the second communication pipe 1092 having lengths or diameters suitable for attenuation of intake noises at desired frequencies and the first volume chamber 1081 and the second volume chamber 1082 may be configured after the air intake device 1001 has been disposed in accordance with the layout of various devices such as the internal combustion engine and an air cleaner disposed before or after the air intake device 1001. Accordingly, the air intake device 1001 can attenuate the intake noises at the desired frequencies without being easily restricted by the layout etc. of the various devices such as the internal combustion engine.

[0091] The intake air flow passage 1010 has the inclined intake air flow passage 1013 inclined downward from the upstream side toward the downstream side. The second communication pipe 1092 is similarly inclined along the inclined intake air flow passage 1013. The second outlet 1121 is positioned on an upper side in the vertical direction than the second inlet 1120 of the second communication pipe 1092. According to the second communication pipe 1092 having such a configuration, moisture can be prevented from entering the second communication pipe 1092 while moving up. Accordingly, the volume of the second volume chamber 1082 can be prevented from varying due to water accumulated in the second volume chamber 1082 through the second communication pipe 1092. Thus, an intake noise attenuation effect achieved by the second resonator 1030 can be maintained excellently.

[0092] Further, in the second communication pipe 1092, the second inlet 1120 is positioned on the downstream side of the intake air flow passage 1010, and the second outlet 121 is positioned on the upstream side of the intake air flow passage 1010. That is, air flowing through the second communication pipe 1092 moves in an opposite direction to the air flow in the intake air flow passage 1010.

[0093] According to the configuration of such a second communication pipe 1092, moisture such as water drops can be more greatly suppressed from entering the second communication pipe 1092 even when the moisture enters the intake air flow passage 1010 together with the air.

[0094] Although Embodiment 1 which is an embodiment of the invention has been described above, the invention is not limited to the aforementioned Embodiment 1. The invention can be changed suitably without departing from its gist.

[0095] Although the first volume chamber 1081 and the second volume chamber 1082 are different in volume, for example, in the aforementioned Embodiment 1, they may be the same in volume. In addition, although one first resonator 1020 is provided in the aforementioned Embodiment 1, a plurality of first resonators 1020 may be provided alternatively. That is, the plurality of first resonators 1020 may be formed by the first member 1040 and the second member 1050. The same rule also applies to the second resonator 1030, i.e. a plurality of second resonators 1030 may be formed by the second member 1050 and the third member 1060.

[0096] Although the first volume chamber 1081 of the first resonator 1020 communicates with the intake air flow passage 1010 through the first communication pipe 1091, it is not limited thereto. That is, the first volume chamber 1081 of the first resonator 1020 may communicate with the intake air flow passage 1010 directly. The same rule also applies to the second resonator 1030, i. e. the second volume chamber 1082 of the second resonator 1030 may communicate with the intake air flow passage 1010 directly.

[0097] Although the intake air flow passage 1010 is formed by the first member 1040 and the second member 1050, the intake air flow passage 1010 may be formed by the second member 1050 and the third member 1060 alternatively. When the intake air flow passage 1010 is formed by the second member 1050 and the third member 1060, it is preferable that the first volume chamber 1081 of the first resonator 1020 is formed to overlap with the intake air flow passage 1010 and extend to the both sides of the intake air flow passage 10 in plan view, and the second volume chamber 1082 of the second resonator 1030 is formed on one side of the intake air flow passage 1010 in plan view. That is, the intake air flow passage 1010, the first resonator 1020 and the second resonator 1030 of the air intake device 1001 according to Embodiment 1 may be disposed to be replaced upside down by one another with respect to the second member 1050. It is a matter of course that the layout of the intake air flow passage 1010, the first resonator 1020 and the second resonator 1030 is not limited to the aforementioned

Embodiment 1.

[0098] Although the second communication pipe 1092 is formed to extend along the air flow of the intake air flow passage 1010, it is not limited thereto. The second communication pipe 1092 may be provided like the first communication pipe 1091 to extend in a direction intersecting with the air flow of the intake air flow passage 1010.

[0099] Although the intake air flow passage 1010 has the inclined intake air flow passage 1013, it is not always limited to such a mode. That is, the intake air flow passage 1010 may be substantially parallel without having the inclined intake air flow passage 1013 or may be inclined upward from the upstream side toward the downstream side. Further, the second outlet 1121 of the second communication pipe 1092 does not have to be located on the upper side than the second inlet 1120 but may be positioned substantially at the same height as the second inlet 1120 or on a lower side than the second inlet 1120.

(Embodiment 2)

[0100] An air intake device of an internal combustion engine according to Embodiment 2 will be described with reference to Figs. 9 to 13. Fig. 9 is a perspective view showing an external appearance of the air intake device. Fig. 10 is an exploded perspective view of the air intake device. Fig. 11 is a plan view of the air intake device. Fig. 12 is a sectional view taken along a line A-A of Fig. 11. Fig. 13 is a sectional view taken along a line B-B of Fig. 11. Fig. 14 is a sectional view taken along a line C-C of Fig. 11. The section taken along the line A-A is a section which passes through an intake air flow passage 2010, a volume chamber 2070, and an outlet 2092. The section taken along the line B-B is a section which does not pass through the outlet 2092 and an inlet 2091 but passes through the intake air flow passage 2010, the volume chamber 2070 and a communication pipe 2020. The section taken along the line C-C is a section which passes through the intake air flow passage 2010, the volume chamber 2070 and the inlet 2091.

[0101] The air intake device 2001 of the internal combustion engine according to Embodiment 2 is provided with the intake air flow passage 2010, and a resonator 2030. The resonator 2030 has the communication pipe 2020 and the volume chamber 2070.

[0102] The intake air flow passage 2010 is a flow passage of air to be fed to the internal combustion engine (not shown). The intake air flow passage 2010 according to Embodiment 2 is constituted by an upstream intake air flow passage 2011, a downstream intake air flow passage 2012, and an inclined intake air flow passage 2013 provided between the upstream intake air flow passage 2011 and the downstream intake air flow passage 2012.

[0103] The upstream intake air flow passage 2011 is a flow passage which has an air intake port (not shown) for taking in air at its one end side and which extends rearward (rearward in an X direction). The inclined intake air flow passage 2013 is a flow passage which continues from the upstream intake air flow passage 2011 and is inclined downward toward the rear. The downstream intake air flow passage 2012 is a flow passage which continues from the inclined intake air flow passage 2013 and extends rearward. A rear side of the downstream intake air flow passage 2012 is connected to the not-shown internal combustion engine. Incidentally, a device such as an air cleaner may be provided on an upstream side of the internal combustion engine on the downstream side of the downstream intake air flow passage 2012.

[0104] The communication pipe 2020 is a pipe provided to extend along the intake air flow passage 2010. In Embodiment 2, the communication pipe 2020 is formed by a first member 2040, a second member 2050 and a third member 2060.

[0105] As will be described later, the communication pipe 2020 has the inlet 2091 and the outlet 2092. The inlet 2091 is an opening on the intake air flow passage 2010 side. The outlet 2092 is an opening on the volume chamber 2070 side. Through such a communication pipe 2020, the intake air flow passage 2010 and the volume chamber 2070 communicate with each other.

[0106] The resonator 2030 is provided with the communication pipe 2020 and the volume chamber 2070. The volume chamber 2070 is a space part having a predetermined volume. The first member 2040, the second member 2050 and the third member 2060 are superimposed on one another in the named order from a lower side in a vertical direction to be integrally formed, thereby the resonator 2030 according to Embodiment 2 is formed.

[0107] A lower-side intake air flow passage forming part 2041 (corresponding to a first intake air flow passage forming part in Claims) which forms a part of the intake air flow passage 2010 on the second member 2050 side is provided in the first member 2040. The lower-side intake air flow passage forming part 2041 is formed into a groove shape which is recessed in section and which is opened to the second member 2050 side. In addition, portions of the lower-side intake air flow passage forming part 2041 which serve as the upstream intake air flow passage 2011 and the downstream intake air flow passage 2012 are substantially horizontal. A portion of the lower-side intake air flow passage forming part 2041 which serves as the inclined intake air flow passage 2013 is inclined downward toward the downstream side.

[0108] A lower-side communication pipe forming part 2042 (corresponding to a first communication pipe forming part in Claims) which forms a part of the communication pipe 2020 on the second member 2050 side is provided in the first member 2040. The lower-side communication pipe forming part 2042 is formed into a groove shape which is recessed in section and which is opened to the second member 2050 side. In addition, the lower-side communication pipe forming part 2042 is provided to extend along the lower-side intake air flow passage forming part 2041. The lower-side communication pipe

forming part 2042 includes a portion which is inclined downward from the front toward the rear in a vehicle front/rear direction.

[0109] The lower-side intake air flow passage forming part 2041 and the lower-side communication pipe forming part 2042 are separated from each other by a wall part 2043. In addition, a portion of the wall part 2043 is notched so that a lower-side inlet 2044 is formed therein. Through the lower-side inlet 2044, one downstream-side end portion of the lower-side intake air flow passage forming part 2041 and one downstream-side end portion of the lower-side communication pipe forming part 2042 communicate with each other.

[0110] An upper-side intake air flow passage forming part 2051 (corresponding to a second intake air flow passage forming part in Claims) which forms a part of the intake air flow passage 2010 on the first member 2040 side is provided in the second member 2050. The upper-side intake air flow passage forming part 2051 is formed into a groove shape which is recessed in section and which is opened to the first member 2040 side. In addition, the upper-side intake air flow passage forming part 2051 is inclined downward from the front toward the rear in the vehicle front/rear direction in line with the inclination of the lower-side intake air flow passage forming part 2041.

[0111] An upper-side communication pipe forming part 2052 (corresponding to a second communication pipe forming part in Claims) which forms a part of the communication pipe 2020 on the first member 2040 side is provided in the second member 2050. The upper-side communication pipe forming part 2052 is formed into a groove shape which is recessed in section and which is opened to the first member 2040 side. In addition, the upper-side communication pipe forming part 2052 is provided to extend along the upper-side intake air flow passage forming part 2051. The upper-side communication pipe forming part 2052 includes a portion inclined downward from the front toward the rear in the vehicle front/rear direction in line with the inclination of the lower-side communication pipe forming part 2042.

[0112] The upper-side intake air flow passage forming part 2051 and the upper-side communication pipe forming part 2052 are separated from each other by a wall part 2053. In addition, a portion of the wall part 2053 is notched so that an upper-side inlet 2056 is formed therein. Through the upper-side inlet 2056, one downstream-side end portion of the upper-side intake air flow passage forming part 2051 and one downstream-side end portion of the upper-side communication pipe forming part 2052 communicate with each other.

[0113] A lower-side volume chamber forming part 2058 (corresponding to a first volume chamber forming part in Claims) which forms a part of the volume chamber 2070 is provided in the second member 2050. The lower-side volume chamber forming part 2058 is the whole of an internal recessed portion which is surrounded by a wall part 2080 provided on an upper face side of the second member 2050. The wall part 2080 is formed so as to surround the inclined intake air flow passage 2013 of the intake air flow passage 2010, a small volume part 2054 which will be described below, and a front-side part of the communication pipe 2020 in plan view.

[0114] The lower-side volume chamber forming part 2058 is constituted by the small volume part 2054 and a large volume part 2057. The small volume part 2054 is a box-like recessed portion which is positioned on one side of the intake air flow passage 2010 in a vehicle width direction and which has a rectangular shape opened to the third member 2060 side. The large volume part 2057 is a recessed portion which is surrounded by the wall part 2080. An upper face of the second member 2050 is used as the bottom of the large volume part 2057.

[0115] The small volume part 2054 is formed to be deepened toward the lower side in the vertical direction, and overlap with the inclined intake air flow passage 2013 in side view. The large volume part 2057 is positioned on an upper side than the inclined intake air flow passage 2013 in side view. In other words, a portion of the bottom of the large volume part 2057 is recessed downward to be formed as the small volume part 2054.

[0116] The outlet 2092 is provided in the second member 2050. The outlet 2092 is a hole which penetrates the second member 2050 in a thickness direction and through which the communication pipe 2020 and the volume chamber 2070 are made to communicate with each other.

[0117] An upper-side volume chamber forming part 2061 (corresponding to a second volume chamber forming part in Claims) which forms a part of the volume chamber 2070 is provided in the third member 2060. The upper-side volume chamber forming part 2061 is formed into a groove shape which is recessed in section and which is opened to the second member 2050 side. In Embodiment 2, the upper-side volume chamber forming part 2061 is formed to be opposed to the lower-side volume chamber forming part 2058.

[0118] Incidentally, although the material of the first member 2040, the second member 2050 and the third member 2060 is not limited particularly, they can be molded and formed out of a resin.

[0119] When the first member 2040, the second member 2050 and the third member 2060 are connected to one another integrally, the air intake device 2001 is formed. The air intake device 2001 is provided with the resonator 2030 and the intake air flow passage 2010. The resonator 2030 has the communication pipe 2020 and the volume chamber 2070.

[0120] That is, one intake air flow passage 2010 in which the opening of the lower-side intake air flow passage forming part 2041 and the opening of the upper-side intake air flow passage forming part 2051 are connected to each other is formed by the first member 2040 and the second member 2050.

[0121] In addition, one communication pipe 2020 in which the opening of the lower-side communication pipe

forming part 2042 and the opening of the upper-side communication pipe forming part 2052 are connected to each other is formed by the first member 2040 and the second member 2050. Further, when the first member 2040 and the second member 2050 are connected to each other, one inlet 2091 is formed out of the lower-side inlet 2044 and the upper-side inlet 2056.

[0122] In addition, one volume chamber 2070 in which the opening of the lower-side volume chamber forming part 2058 and the opening of the upper-side volume chamber forming part 2061 are connected to each other is formed by the second member 2050 and the third member 2060.

[0123] Such a communication pipe 2020 communicates with the intake air flow passage 2010 through the inlet 2091 on the downstream side of the intake air flow passage 2010. The volume chamber 2070 communicates with the communication pipe 2020 through the outlet 2092.

[0124] A part of the second member 2050 to which the third member 2060 is connected is a top face 2081 of the wall part 2080 which forms the lower-side volume chamber forming part 2058. The top face 2081 is an approximately horizontal face facing the third member 2060 side. On the other hand, although not shown particularly, a part of the third member 2060 to which the second member 2050 is connected is also an approximately horizontal flat face which has the same shape as the top face 2081 and which faces the second member 2050 side.

[0125] Thus, the second member 2050 and the third member 2060 are connected to each other at their horizontal faces. Therefore, a gap is hardly generated between the second member 2050 and the third member 2060. Thus, airtightness of the second volume chamber 2070 formed by the second member 2050 and the third member 2060 can be improved.

[0126] In Embodiment 2, the intake air flow passage 2010 has the inclined intake air flow passage 2013 which is inclined. In order to form the inclined intake air flow passage 2013, the upper-side intake air flow passage forming part 2051 of the second member 2050 is inclined. Thus, although the second member 2050 includes the inclined part, the face where the second member 2050 is connected to the third member 2060 can be formed as a horizontal face due to the provision of the wall part 2080.

[0127] An air flow in the air intake device 2001 having such a configuration will be described with reference to Fig. 15. Fig. 15 is a plan view of the air intake device showing the air flow. The third member 2060 is not shown in Fig. 15.

[0128] As indicated by an arrow L, external air flows into the intake air flow passage 2010 to be sent out to the internal combustion engine from the downstream intake air flow passage 2012. In addition, as indicated by an arrow M, a part of the air flowing into the intake air flow passage 2010 flows into the communication pipe 2020 from the inlet 2091. The air flowing through the communication pipe 2020 reaches the volume chamber 2070 from the outlet 2092.

[0129] The air intake device 2001 of the internal combustion engine having the aforementioned configuration is provided with the communication pipe 2020 through which the intake air flow passage 2010 and the volume chamber 2070 communicate with each other. That is, the volume chamber 2070 is connected to the intake air flow passage 2010 not directly but indirectly through the communication pipe 2020. When the length or diameter of the communication pipe 2020 is adjusted suitably, a frequency of resonance sound attenuated in the volume chamber 2070 can be set as a desired frequency.

[0130] In order to attenuate resonance sound at the desired frequency, in the background art, the size of the volume chamber or the layout of the volume chamber 2070 with respect to the intake air flow passage 2010 has to be changed. On the other hand, in the air intake device 2001 according to Embodiment 2, the communication pipe 2020 may be configured to have a length or diameter suitable for attenuation of the resonance sound at the desired frequency after the volume chamber 2070 has been disposed in accordance with the layout of various devices such as the internal combustion engine, the intake air flow passage 2010 and an air cleaner disposed on the intake air flow passage 2010. Accordingly, the air intake device 2001 can attenuate the resonance sound at the desired frequency without being easily restricted by the layout etc. of the various devices such as the intake air flow passage 2010.

[0131] In Embodiment 2, the length of the communication pipe 2020 extends from the inlet 2091 to the outlet 2092. When the position of the inlet 2091 or the outlet 2092 is adjusted, the length of the communication pipe 2020 can be adjusted easily. That is, when the position of the inlet 2091 or the outlet 2092 is adjusted, the communication pipe 2020 can be formed to have any length without the necessity of changing any other member. Thus, when only a small number of members are changed, the air intake device 2001 for attenuating resonance sound at a desired frequency can be configured.

[0132] In addition, the communication pipe 2020 is provided to extend along the intake air flow passage 2010. Therefore, a required space for the communication pipe 2020 is only around the intake air flow passage 2010. Since a space where the intake air flow passage 2010 should be disposed is originally provided in a vehicle, there is little fear that the space required for forming the communication pipe 2020 may interfere with any other device. Thus, the length of the communication pipe 2020 can be secured sufficiently to attenuate resonance sound, and space saving can be achieved.

[0133] Further, in the communication pipe 2020, the inlet 2091 which is formed as an entrance of air is positioned on the downstream side of the intake air flow passage 2010, and the outlet 2092 which is formed as an exit of the air is positioned on the upstream side of the intake air flow passage 2010. That is, air flowing through the communication pipe 2020 moves in an opposite di-

rection to an air flow in the intake air flow passage 2010.

[0134] According to such a configuration of the communication pipe 2020, even when moisture such as water drops enters the intake air flow passage 2010 together with air, the moisture can be suppressed from entering the communication pipe 2020. Accordingly, the volume of the volume chamber 2070 can be prevented from varying due to water accumulated in the volume chamber 2070 through the communication pipe 2020. Thus, a resonance sound attenuation effect achieved by the volume chamber 2070 can be maintained excellently.

[0135] Incidentally, when moisture enters the communication pipe 2020, the moisture is accumulated in the volume chamber 2070. When the moisture is accumulated in the volume chamber 2070, the volume of the volume chamber 2070 varies so that resonance sound having a desired frequency cannot be attenuated.

[0136] The intake air flow passage 2010 has the inclined intake air flow passage 2013 inclined downward from the upstream side toward the downstream side. Similarly, the communication pipe 2020 is inclined along the inclined intake air flow passage 2013. The outlet 2092 is positioned on the upper side than the inlet 2091 of the communication pipe 2020. Since it is almost impossible for moisture to enter such a communication pipe 2020 while moving up along the communication pipe 2020, moisture can be more surely prevented from entering the communication pipe 2020.

[0137] In addition, the small volume part 2054 of the volume chamber 2070 is formed to overlap with the inclined intake air flow passage 2013 in side view. Thus, a space occupied by the volume chamber 2070 can be reduced in a height direction. When the small volume part 2054 is made not to overlap with the inclined intake air flow passage 2013, the upper-side volume chamber forming part 2061 has to be enlarged upward by the volume of the small volume part 2054. Therefore, the air intake device 2001 requires a larger space in the height direction.

[0138] Further, the air intake device 2001 according to Embodiment 2 is provided with the first member 2040, the second member 2050 and the third member 2060 which are superimposed on one another to be formed integrally. Thus, the intake air flow passage 2010, the volume chamber 2070 and the communication pipe 2020 can be formed integrally so that the components can be arranged compactly. Incidentally, in the background art, the intake air flow passage 2010, and the resonator 2030 which is provided with the communication pipe 2020 and the volume chamber 2070 are formed by separate members. Accordingly, the number of components increases, and labor and time for assembling the resonator 2030 with the intake air flow passage 2010 increase. In addition, even when the intake air flow passage 2010 and the volume chamber 2070 are intended to be formed integrally by one member, it is difficult that the intake air flow passage 2010 and the volume chamber 2070 are formed to overlap with each other vertically in plan view.

(Embodiment 3)

[0139] An air intake device of an internal combustion engine according to Embodiment 3 will be described with reference to Figs. 16 to 19. Fig. 16 is a plan view showing an external appearance of the air intake device. Fig. 17 is a side view of the air intake device. Fig. 18 is a perspective view of the air intake device. Fig. 19 is a sectional view taken along a line D-D of Fig. 16. A third member is not shown in Fig. 18. In addition, the section taken along the line D-D is a section which passes through an intake air flow passage 2110, a volume chamber 2170, a communication pipe 2120, an inlet 2191 and an outlet 2192.

[0140] The air intake device 2001A of the internal combustion engine according to Embodiment 3 is provided with the intake air flow passage 2110, and a resonator 2130. The resonator 2130 has the communication pipe 2120 and the volume chamber 2170. In addition, the air intake device 2001A is provided with a housing chamber 2180 in which the communication pipe 2120 is housed.

[0141] The intake air flow passage 2110 is a flow passage of air to be fed to the internal combustion engine (not shown). In Embodiment 3, the intake air flow passage 2110 is constituted by an upstream intake air flow passage 2111 and an inclined intake air flow passage 2113.

[0142] The upstream intake air flow passage 2111 is a flow passage which has an air intake port (not shown) for taking in air at its one end side and which extends rearward (toward the rear in an X direction). The inclined intake air flow passage 2113 is a flow passage which continues from the upstream intake air flow passage 2111 and is inclined downward toward the rear. A rear side of the inclined intake air flow passage 2113 is connected to the not-shown internal combustion engine.

[0143] Incidentally, a device such as an air cleaner may be provided on an upstream side of the internal combustion engine on the downstream side of the inclined intake air flow passage 2113. The communication pipe 2120 is a pipe which branches from the intake air flow passage 2110 and is provided to extend along the intake air flow passage 2110. In Embodiment 3, the communication pipe 2120 is formed out of a separate member from a first member 2140, a second member 2150 and a third member 2160. That is, the communication pipe 2120 is not formed by the first member 2140, the second member 2150 and the third member 2160 integrally with the resonator 2130.

[0144] The resonator 2130 is provided with the communication pipe 2120 and the volume chamber 2170. The volume chamber 2170 is a space part having a predetermined volume. The resonator 2130 according to Embodiment 3 is formed when the first member 2140, the second member 2150 and the third member 2160 are connected in the named order from a lower side in a vertical direction.

[0145] A lower-side intake air flow passage forming

part 2141 (corresponding to a first intake air flow passage forming part in Claims) which forms a part of the intake air flow passage 2110 is provided in the first member 2140. The lower-side intake air flow passage forming part 2141 is formed into a groove shape which is recessed in section and which is opened to the second member 2150 side. In addition, a portion of the lower-side intake air flow passage forming part 2141 which serves as the upstream intake air flow passage 2111 extends substantially horizontally from the front toward the rear in a vehicle front/rear direction. A portion of the lower-side intake air flow passage forming part 2141 which starts from a midway place thereof to serve as the inclined intake air flow passage 2113 is inclined downward from the front toward the rear.

[0146] The volume chamber 2170 which is opened to the second member 2150 side is provided in the first member 2140. The volume chamber 2170 communicates with the housing chamber 2180 to thereby form one space. The housing chamber 2180 will be described later. In addition, the volume chamber 2170 is formed to be deepened toward the lower side in the vertical direction and overlap with the intake air flow passage 2110 in side view.

[0147] An upper-side intake air flow passage forming part 2151 (corresponding to a second intake air flow passage forming part in Claims) which forms a part of the intake air flow passage 2110 is provided in the second member 2150. The upper-side intake air flow passage forming part 2151 is formed into a groove shape which is recessed in section and which is opened to the first member 2140 side. In addition, a portion of the upper-side intake air flow passage forming part 2151 which serves as the upstream intake air flow passage 2111 extends substantially horizontally from the front toward the rear in the vehicle front/rear direction. A portion of the upper-side intake air flow passage forming part 2151 which starts from a midway place thereof to serve as the inclined intake air flow passage 2113 is inclined downward from the front toward the rear.

[0148] A branch opening 2144 which penetrates the second member 2150 in a thickness direction to communicate with the upper-side intake air flow passage forming part 2151 is provided in the second member 2150. The branch opening 2144 is formed into a cylindrical shape which protrudes upward from the second member 2150 in the vertical direction. The branch opening 2144 is positioned on a downstream side of the intake air flow passage 2110.

[0149] A lower-side housing chamber forming part 2158 (corresponding to a first housing chamber forming part in Claims) which forms a part of the housing chamber 2180 on the third member 2160 side is provided in the second member 2150. The lower-side housing chamber forming part 2158 is formed into a recess shape which is opened to the third member 2160 side. A communication opening part 2159 penetrating the second member 2150 is formed in a region of the second member 2150 opposed to the volume chamber 2170. The lower-side housing chamber forming part 2158 is a recessed part of the second member 2150 facing the third member 2160 except the communication opening part 2159.

[0150] An upper-side housing chamber forming part 2161 (corresponding to a second housing chamber forming part in Claims) which forms a part of the housing chamber 2180 on the second member 2150 side is provided in the third member 2160. The upper-side housing chamber forming part 2161 is formed into a groove shape which is recessed in section and which is opened to the second member 2150 side. In Embodiment 3, the upper-side housing chamber forming part 2161 is formed to be opposed to the lower-side housing chamber forming part 2158 and the volume chamber 2170.

[0151] Incidentally, although the material of the first member 2140, the second member 2150 and the third member 2160 is not limited particularly, they can be molded and formed out of a resin.

[0152] When the first member 2140, the second member 2150 and the third member 2160 are connected integrally, the air intake device 2001A provided with the resonator 2130 and the intake air flow passage 2110 is formed. The resonator 2130 has the communication pipe 2120 which is housed in the housing chamber 2180, and the volume chamber 2170.

[0153] That is, one intake air flow passage 2110 in which the opening of the lower-side intake air flow passage forming part 2141 and the opening of the upper-side intake air flow passage forming part 2151 are connected to each other is formed by the first member 2140 and the second member 2150.

[0154] In addition, one housing chamber 2180 in which the opening of the lower-side housing chamber forming part 2158 and the opening of the upper-side housing chamber forming part 2161 are connected to each other is formed by the second member 2150 and the third member 2160. The housing chamber 2180 formed thus communicates with the volume chamber 2170 so that one integrated volume chamber including the housing chamber 2180 and the volume chamber 2170 is formed. That is, the housing chamber 2180 and the volume chamber 2170 are integrated to generate an effect and a function for attenuating intake noise.

[0155] The communication pipe 2120 is housed inside the housing chamber 2180. In addition, the communication pipe 2120 has the inlet 2191 as one opening and the outlet 2192 as the other opening. The inlet 2191 is connected to the branch opening 2144. The outlet 2192 is positioned inside the housing chamber 2180. Through such a communication pipe 2120, the volume chamber 2170 and the intake air flow passage 2110 communicate with each other.

[0156] An air flow in the air intake device 2001A having such a configuration will be described with reference to Figs. 18 and 19.

[0157] Air fed from the outside flows into the intake air flow passage 2110 to be sent out to the internal combus-

tion engine from the inclined intake air flow passage 2113. In addition, as indicated by an arrow M, a part of the air flowing into the intake air flow passage 2110 flows into the communication pipe 2120 from the inlet 2191. The air flowing through the communication pipe 2120 reaches the housing chamber 2180 and the volume chamber 2170 from the outlet 2192.

[0158] The air intake device 2001A of the internal combustion engine having the aforementioned configuration is provided with the communication pipe 2120 through which the intake air flow passage 2110 and the volume chamber 2170 communicate with each other. That is, the volume chamber 2170 is connected to the intake air flow passage 2110 not directly but indirectly through the communication pipe 2120. When the length or diameter of the communication pipe 2120 is adjusted suitably, a frequency of resonance sound to be attenuated in the volume chamber 2170 can be set as a desired frequency.

[0159] In order to attenuate resonance sound at the desired frequency, in the background art, the size of the volume chamber or the layout of the volume chamber 2170 with respect to the intake air flow passage 2110 has to be changed. On the other hand, in the air intake device 2001A according to the Embodiment 3, the communication pipe 2120 may be configured to have a length or diameter suitable for attenuation of the resonance sound at the desired frequency after the volume chamber 2170 has been disposed in accordance with the layout of various devices such as the internal combustion engine, the intake air flow passage 2110 and an air cleaner disposed on the intake air flow passage 2110. Accordingly, the air intake device 2001A can attenuate the resonance sound at the desired frequency without being easily restricted by the layout of the various devices such as the intake air flow passage 2110.

[0160] In Embodiment 3, the communication pipe 2120 is a separate body from the first member 2140, the second member 2150 and the third member 2160. Accordingly, when only the length or diameter of the communication pipe 2120 is changed, the air intake device 2001A for attenuating resonance sound at a desired frequency can be configured.

[0161] In addition, the communication pipe 2120 is provided to extend along the intake air flow passage 2110. Therefore, a required space for the communication pipe 2120 is only around the intake air flow passage 2110. Since a space where the intake air flow passage 2110 should be disposed is originally provided in a vehicle, there is little fear that the space required for forming the communication pipe 2120 may interfere with any other device. Thus, the length of the communication pipe 2120 can be secured sufficiently to attenuate resonance sound, and space saving can be achieved.

[0162] Further, the communication pipe 2120 has the inlet 2191 as an entrance of air and the outlet 2192 as an exit of the air. The inlet 2191 is positioned on the downstream side of the intake air flow passage 2110. The outlet 2192 is positioned on the upstream side of the intake air flow passage 2110. That is, air flowing through the communication pipe 2120 moves in an opposite direction to an air flow in the intake air flow passage 2110.

[0163] According to such a configuration of the communication pipe 2120, even when moisture such as water drops together with air enters the intake air flow passage 2110, the moisture can be suppressed from entering the communication pipe 2120. Accordingly, the volume of the volume chamber 2170 can be prevented from varying due to water accumulated in the volume chamber 2170 through the communication pipe 2120. Thus, a resonance sound attenuation effect achieved by the volume chamber 2170 can be maintained excellently.

[0164] In addition, the inlet 2191 of the communication pipe 2120 faces down in the vertical direction. Since the inlet 191 is formed thus, it is almost impossible for moisture to move up from the intake air flow passage 2110 and enter the communication pipe 2120. Accordingly, the moisture can be more surely prevented from entering the communication pipe 2120.

[0165] In addition, the inclined intake air flow passage 2113 constituting a part of the intake air flow passage 2110 is inclined downward from the front toward the rear in the vehicle front/rear direction. The communication pipe 2120 is similarly inclined along the inclined intake air flow passage 2113. The outlet 2192 is positioned on an upper side than the inlet 2191 in the communication pipe 2120.

[0166] It is almost impossible for moisture to enter the communication pipe 2120 while moving up along the communication pipe 2120. Accordingly, the moisture can be more surely prevented from entering the communication pipe 2120.

[0167] In addition, the volume chamber 2170 is formed to overlap with the inclined intake air flow passage 2113 in side view. Thus, the space which is occupied by the volume chamber 2170 can be reduced in a height direction. When the volume chamber 2170 is made not to overlap with the inclined intake air flow passage 2113, the upper-side housing chamber forming part 2161 has to be enlarged upward by the volume of the volume chamber 2170. Therefore, the air intake device 2001A requires a larger space in the height direction.

[0168] Further, the air intake device 2001A according to Embodiment 3 is provided with the first member 2140, the second member 2150 and the third member 2160 which are superimposed on one another to be formed integrally. Thus, the intake air flow passage 2110 and the volume chamber 2170 can be formed integrally so that the components can be arranged compactly.

[0169] Although Embodiment 2 and Embodiment 3 as embodiments of the invention have been described above, the invention is not limited to the aforementioned Embodiment 2 and the aforementioned Embodiment 3. The invention can be changed suitably without departing from its gist.

[0170] Although the directions of air flows in the communication pipe 2020 and the communication pipe 2120

are opposite to the directions of air flows in the intake air flow passage 2010 and the intake air flow passage 2110 respectively, for example, in the aforementioned Embodiment 2 and the aforementioned Embodiment 3, the communication pipe 2020 and the communication pipe 2120 are not limited to such modes. That is, the communication pipe 2020 and the communication pipe 2120 may be provided to extend at least along the intake air flow passage 2010 and the intake air flow passage 2110 respectively, and the directions of air flows in the communication pipe 2020 and the communication pipe 2120 may be the same as the directions of air flows in the intake air flow passage 2010 and the intake air flow passage 2110 respectively.

[0171] Although the intake air flow passage 2010 and the intake air flow passage 2110 have the inclined intake air flow passage 2013 and the inclined intake air flow passage 2113 respectively, they are not limited to such modes. That is, the intake air flow passage 2010 and the intake air flow passage 2110 may be made substantially parallel without having the inclined intake air flow passage 2013 and the inclined intake air flow passage 2113 respectively, or may be inclined upward from the upstream side toward the downstream side. Further, the outlet 2092 of the communication pipe 2020 and the outlet 2192 of the communication pipe 2120 do not have to be located on the upper sides than the inlet 2091 and the inlet 2191 respectively but may be positioned at substantially the same heights as or on lower sides than the inlet 2091 and the inlet 2191 respectively.

[0172] Although the volume chamber 2070 and the volume chamber 2170 are formed to overlap with the inclined intake air flow passage 2013 and the inclined intake air flow passage 2113 in side view, they are not limited to such modes. That is, the volume chamber 2070 and the volume chamber 2170 do not overlap with the inclined intake air flow passage 2013 and the inclined intake air flow passage 2113 respectively in side view but may be positioned on the upper sides or the lower sides than the inclined intake air flow passage 2013 and the inclined intake air flow passage 2113 respectively.

[0173] Although the inlet 2191 of the communication pipe 2120 faces down, it is not limited to such a mode but may face in any direction.

[0174] Although the resonator 2030 is constituted by the first member 2040, the second member 2050 and the third member 2060, and the resonator 2130 is constituted by the first member 2140, the second member 2150 and the third member 2160, the resonator 2030 and the resonator 2130 are not limited to such modes. Each of the inclined intake air flow passage 2013, the communication pipe 2020 and the volume chamber 2070 may be constituted by one and the same member or may be constituted by two members or by four or more members. The same rule may also apply to the resonator 2130.

[0175] In addition, the resonator 2030 is provided with one communication pipe 2020 and one volume chamber 2070. However, the resonator 2030 may be alternatively provided with two or more communication pipes 2020 and two or more volume chambers 2070. The same rule may also apply to the resonator 2130.

[0176] The invention can be used in a car industrial field.

Claims

1. An air intake device of an internal combustion engine, the air intake device comprising:

   a first resonator and a second resonator which have a first volume chamber and a second volume chamber, respectively, the first and second volume chambers communicating with an intake air flow passage feeding air to the internal combustion engine; and
   a first member, a second member and a third member which form the first resonator and the second resonator,

   characterized in that:

   the first resonator is formed by the first member and the second member; and
   the second resonator is formed by the second member and the third member.

2. The air intake device according to claim 1, **characterized in that**
   volume of the first volume chamber is different from volume of the second volume chamber.

3. The air intake device according to claim 1 or claim 2, **characterized in that**
   the intake air flow passage is formed by the second member and the third member.

4. The air intake device according to claim 1 or claim 2, **characterized in that**
   the intake air flow passage is formed by the first member and the second member.

5. The air intake device according to claim 4, **characterized in that**:

   the first resonator is formed on one side of the intake air flow passage in plan view; and
   the second resonator is formed to overlap with the intake air flow passage and extend to both sides of the intake air flow passage in plan view.

6. The air intake device according to any one of claims 3 to 5, **characterized in that**:

   the first resonator is provided with a first communication pipe which branches from the intake air flow passage to communicate with the first

volume chamber;
the second resonator is provided with a second communication pipe which branches from the intake air flow passage to communicate with the second volume chamber; and
at least one of the first communication pipe and the second communication pipe is provided to extend in a direction along an air flow of the intake air flow passage.

7. The air intake device according to claim 6, **characterized in that**
length of the first communication pipe is different from length of the second communication pipe.

8. The air intake device according to claim 6 or claim 7, **characterized in that**:

the intake air flow passage is formed by the first member and the second member to be inclined downward from an upstream side toward a downstream side;
the first volume chamber is formed on one side of the intake air flow passage in plan view;
the second volume chamber is formed to overlap with the intake air flow passage and extend to both sides of the intake air flow passage in plan view;
the second communication pipe is provided to extend in the direction along the air flow of the intake air flow passage; and
an outlet of the second communication pipe connected to the second volume chamber is positioned on an upper side than an inlet of the second communication pipe connected to the intake air flow passage.

9. An air intake device of an internal combustion engine, the air intake device comprising:

an intake air flow passage which is a flow passage of air to be fed to the internal combustion engine; and
a resonator which includes a communication pipe communicating with the intake air flow passage, and a volume chamber communicating with the intake air flow passage through the communication pipe,

characterized in that
the communication pipe is provided to extend along the intake air flow passage.

10. The air intake device according to claim 9, **characterized in that**
a direction of an air flow in the communication pipe is opposite to a direction of an air flow in the intake air flow passage.

11. The air intake device according to claim 9 or claim 10, **characterized in that**
an inlet of the communication pipe which is an opening on a side of the intake air flow passage faces down.

12. The air intake device according to any one of claims 9 to 11, **characterized in that**:

the intake air flow passage is inclined downward from an upstream side toward a downstream side; and
an outlet of the communication pipe which is an opening on a side of the volume chamber is positioned on an upper side than an inlet of the communication pipe which is an opening on a side of the intake air flow passage.

13. The air intake device according to claim 12, **characterized in that**
the intake air flow passage includes an inclined intake air flow passage which is inclined downward from the upstream side toward the downstream side; and the volume chamber is formed to overlap with the inclined intake air flow passage in side view.

14. The air intake device according to any one of claims 9 to 13, **characterized in that**:

a first member, a second member and a third member which are superimposed on one another to be formed integrally to thereby form the intake air flow passage, the communication pipe and the volume chamber are provided;
the first member includes a first intake air flow passage forming part forming a part of the intake air flow passage on a side of the second member, and a first communication pipe forming part forming a part of the communication pipe on a side of the second member;
the second member includes a second intake air flow passage forming part forming a part of the intake air flow passage on a side of the first member, a second communication pipe forming part forming a part of the communication pipe on a side of the first member, and a first volume chamber forming part forming a part of the volume chamber on a side of the third member;
the third member includes a second volume chamber forming part forming a part of the volume chamber on a side of the second member;
the intake air flow passage is formed out of the first intake air flow passage forming part and the second intake air flow passage forming part;
the communication pipe is formed out of the first communication pipe forming part and the second communication pipe forming part; and
the volume chamber communicating with the

communication pipe is formed out of the first volume chamber forming part and the second volume chamber forming part.

15. The air intake device according to any one of claims 9 to 13, **characterized in that**:

a first member, a second member and a third member which are superimposed on one another to be formed integrally to thereby form the intake air flow passage, a housing chamber for housing the communication pipe, and the volume chamber are provided;
the first member includes a first intake air flow passage forming part forming a part of the intake air flow passage on a side of the second member, and the volume chamber opened to a side of the second member;
the second member includes a second intake air flow passage forming part forming a part of the intake air flow passage on a side of the first member, and a first housing chamber forming part forming a part of the housing chamber on a side of the third member;
the third member includes a second housing chamber forming part forming a part of the housing chamber on a side of the second member;
the intake air flow passage is formed out of the first intake air flow passage forming part and the second intake air flow passage forming part;
the housing chamber is formed out of the first housing chamber forming part and the second housing chamber forming part;
the volume chamber and the housing chamber communicate with each other; and
the communication pipe is housed in the housing chamber, and the housing chamber and the intake air flow passage communicate with each other through the communication pipe.

FIG. 1

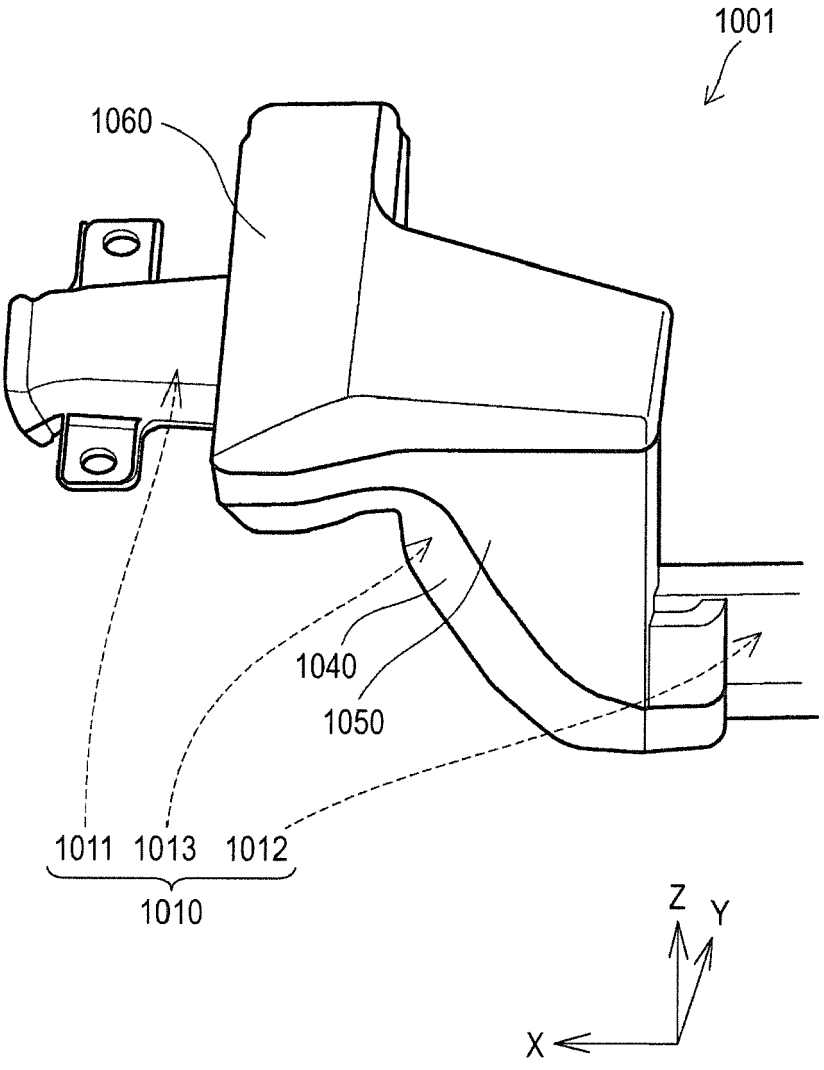

FIG. 2

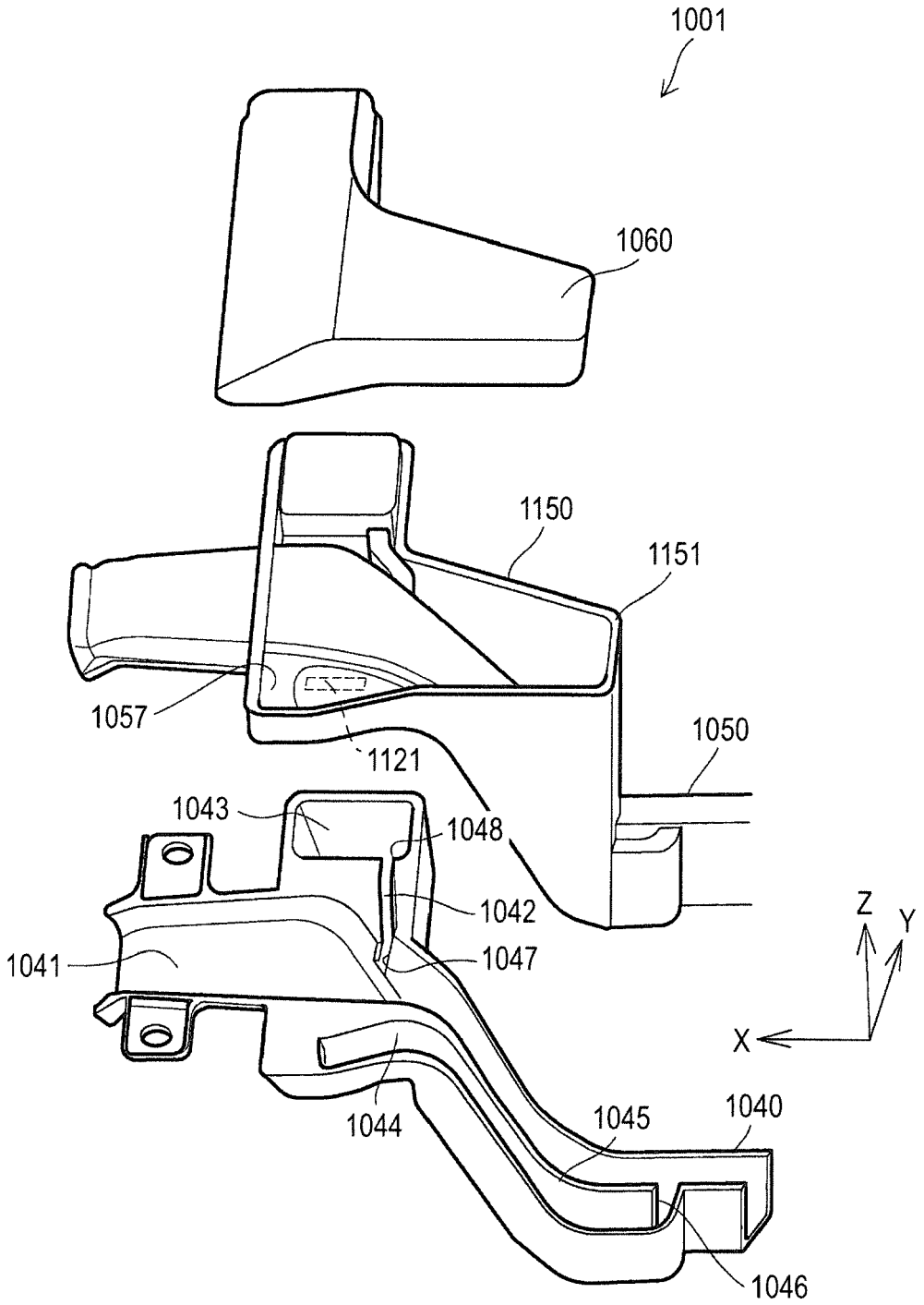
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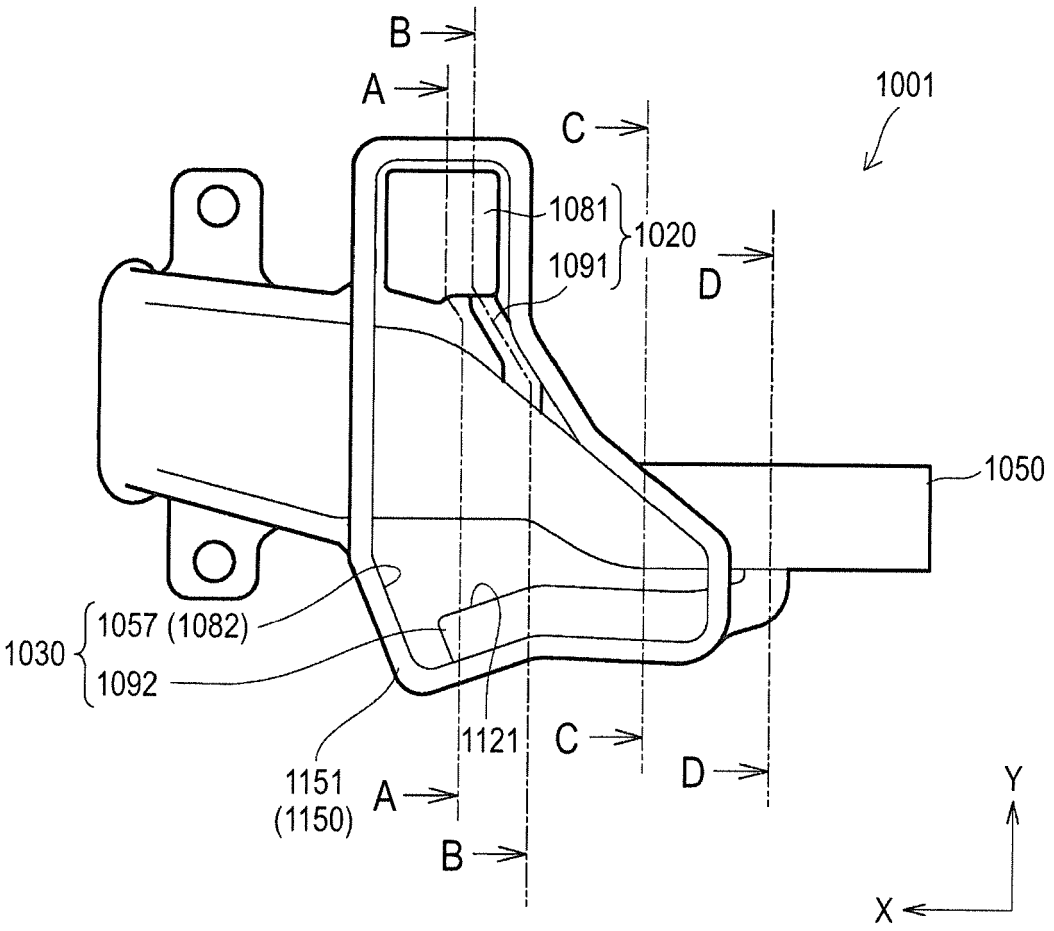
FIG. 3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C
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1091
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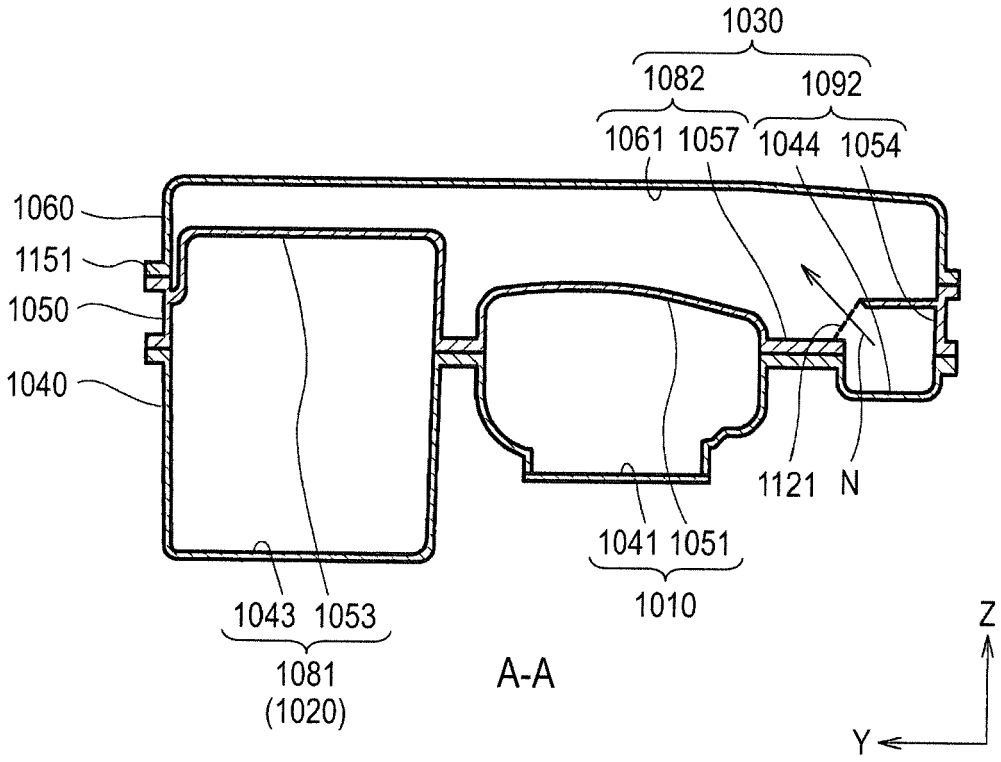
(1150)
A
D
B
Y
X

FIG. 4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(1020)
A-A
Z
Y

FIG. 5

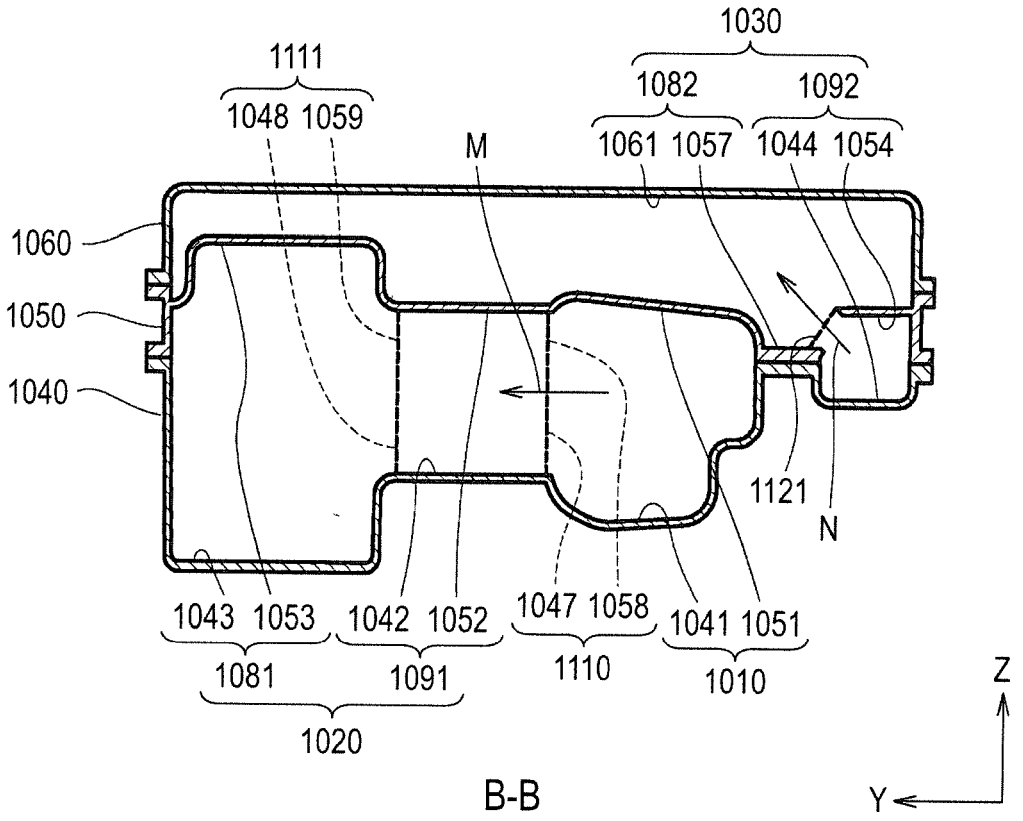
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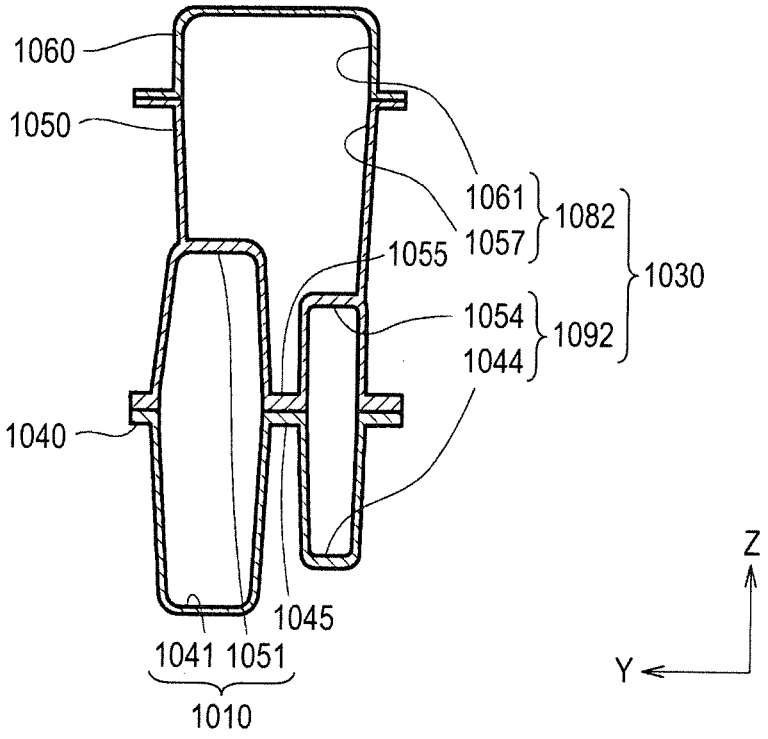
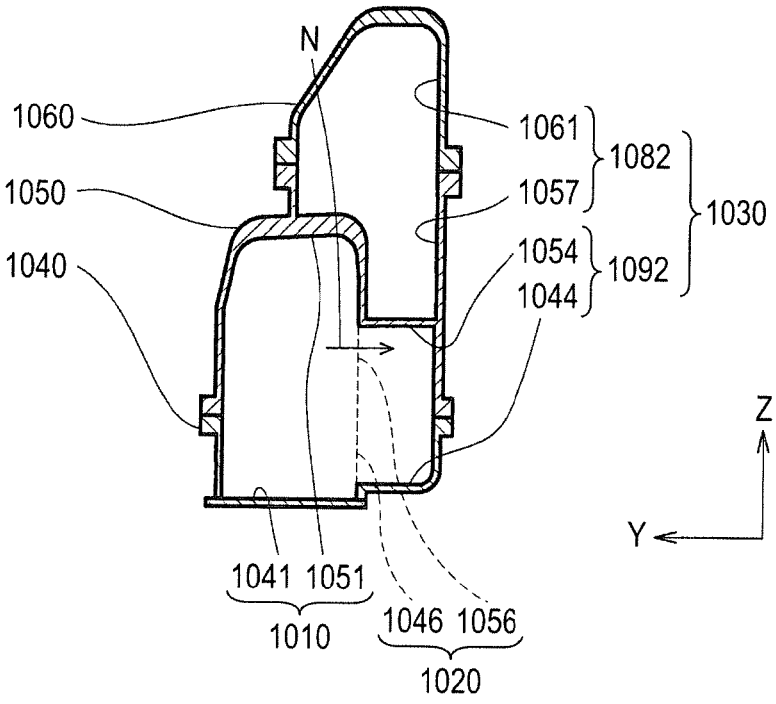
FIG. 6



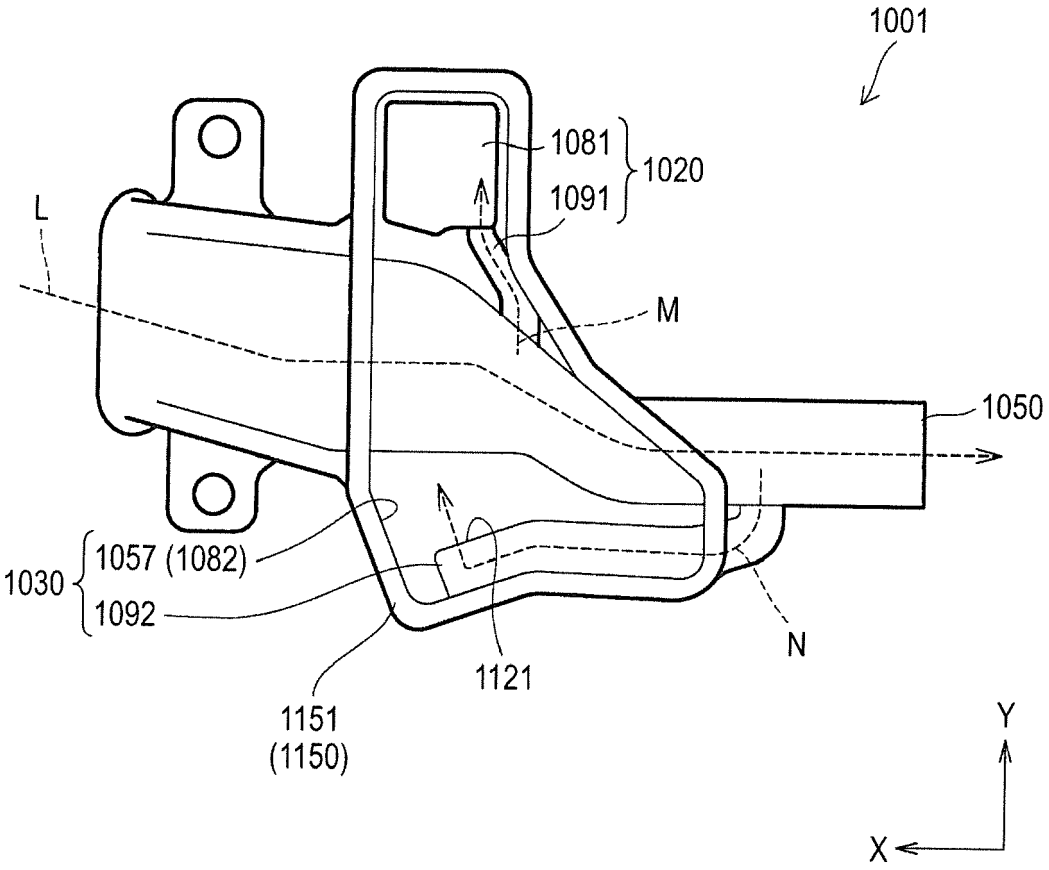
C-C

FIG. 7



D-D

FIG. 8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1092
1121
N
1151
(1150)
Y
X

FIG. 9

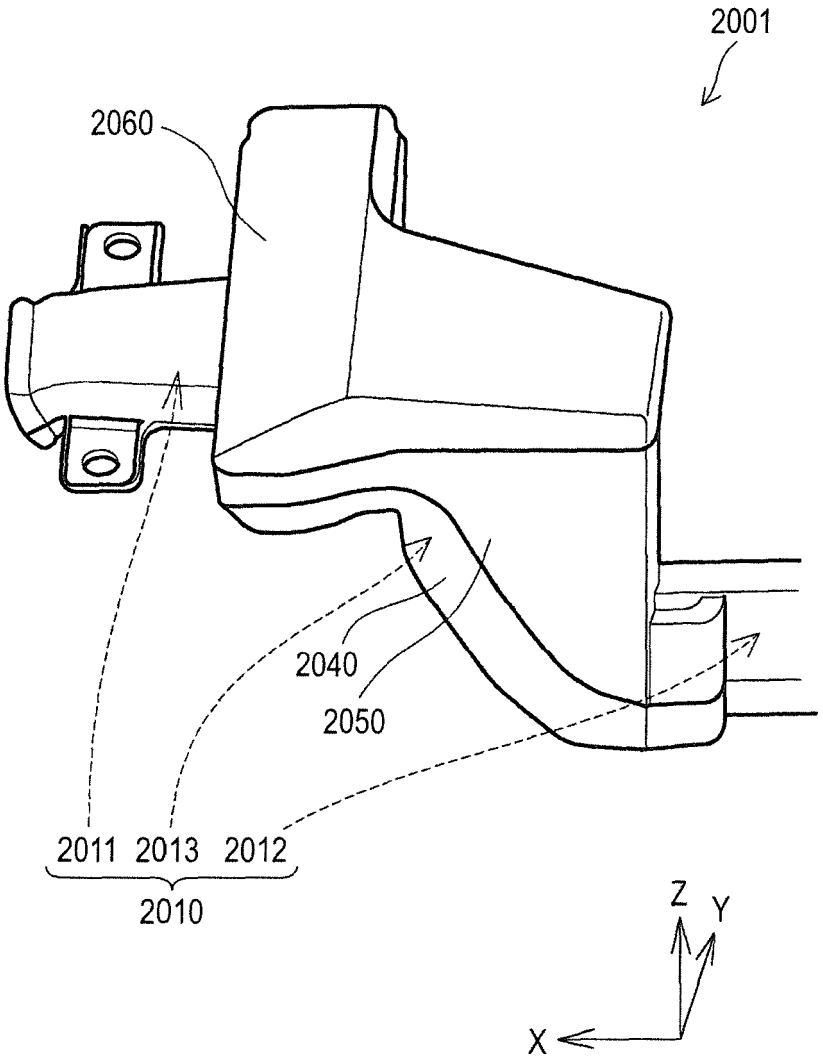

FIG. 10

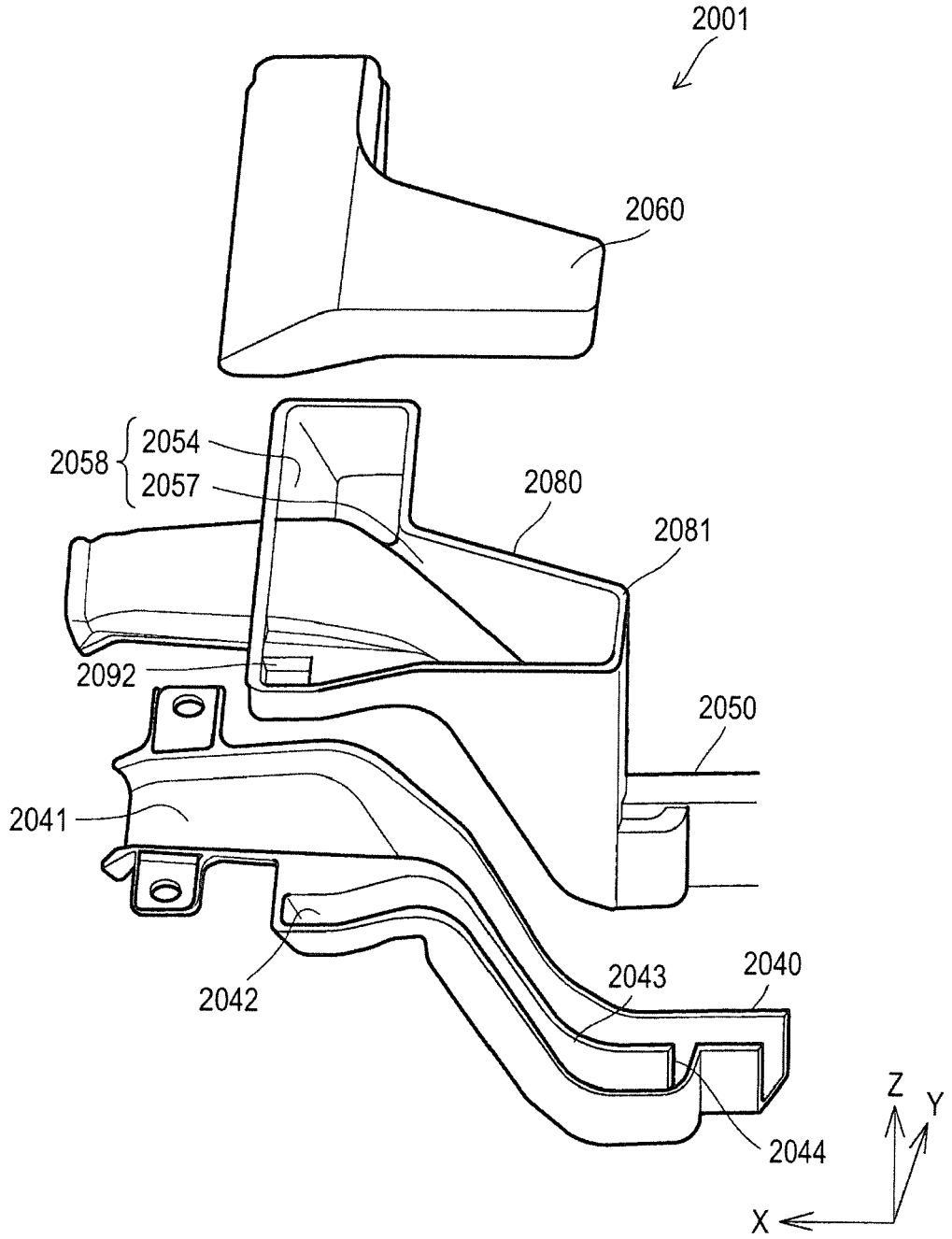
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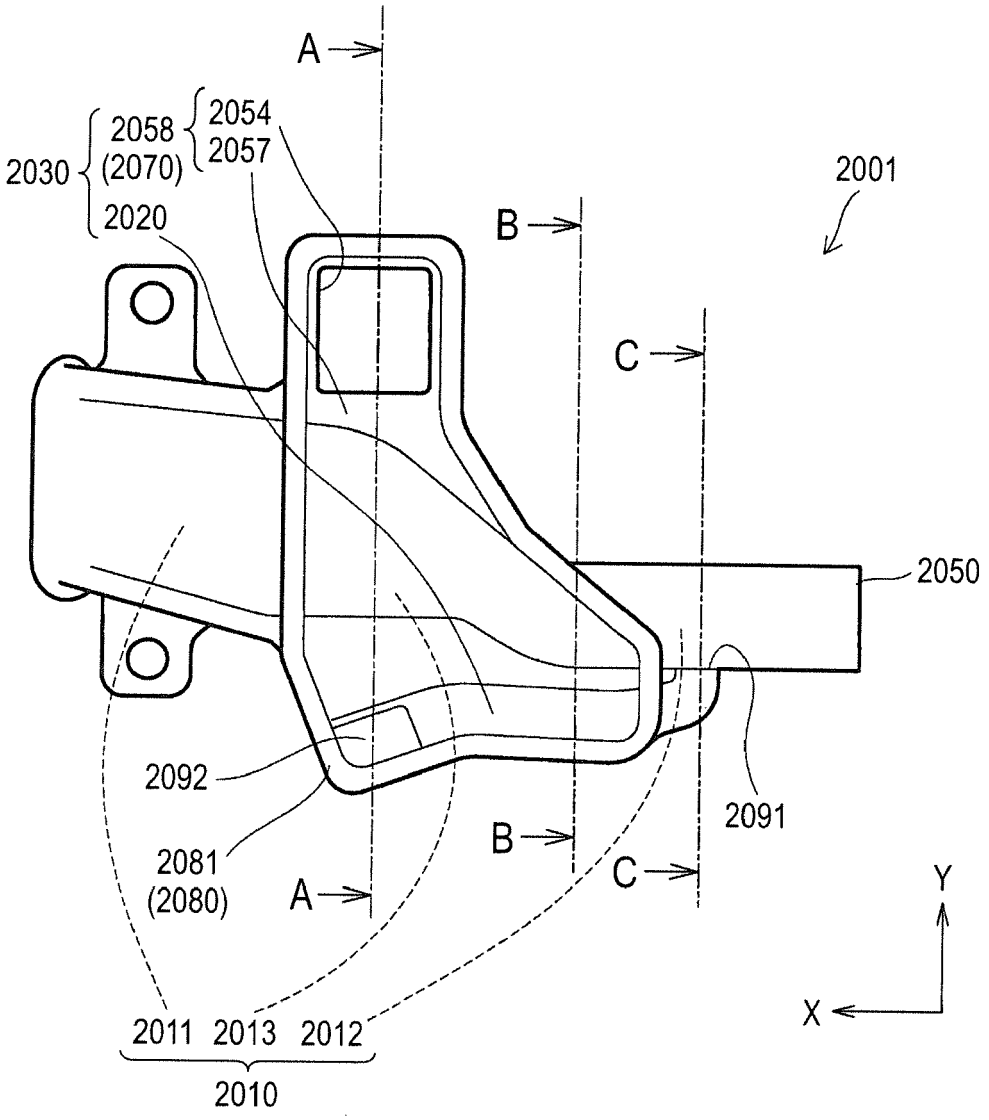
FIG. 11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(2070)
2054
2057
2020
2001
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C
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2092
2081
(2080)
2091
B
C
A
Y
X
2011
2013
2012
2010

FIG. 12

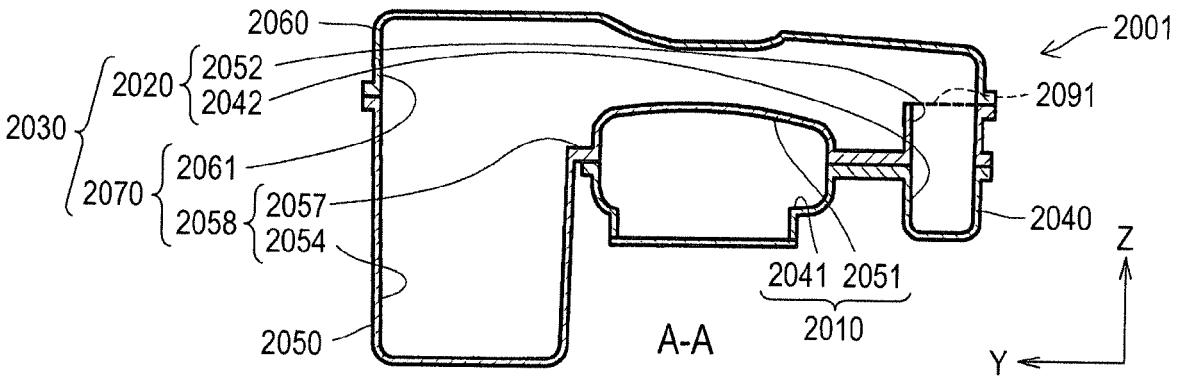


FIG. 13

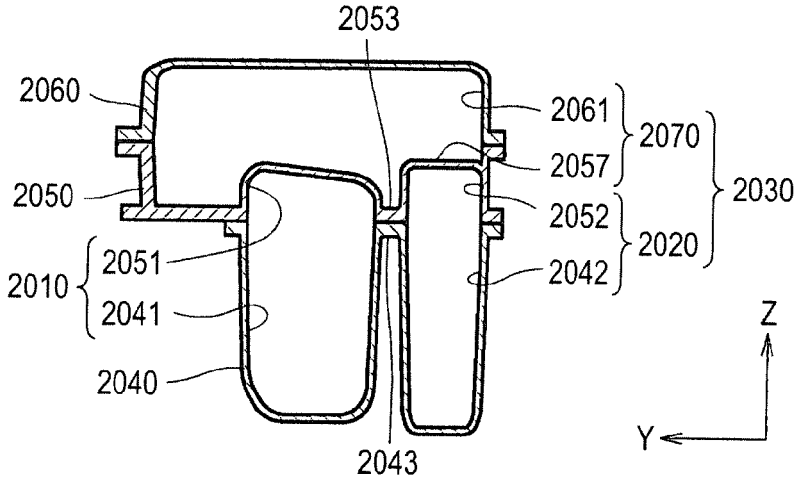


FIG. 14

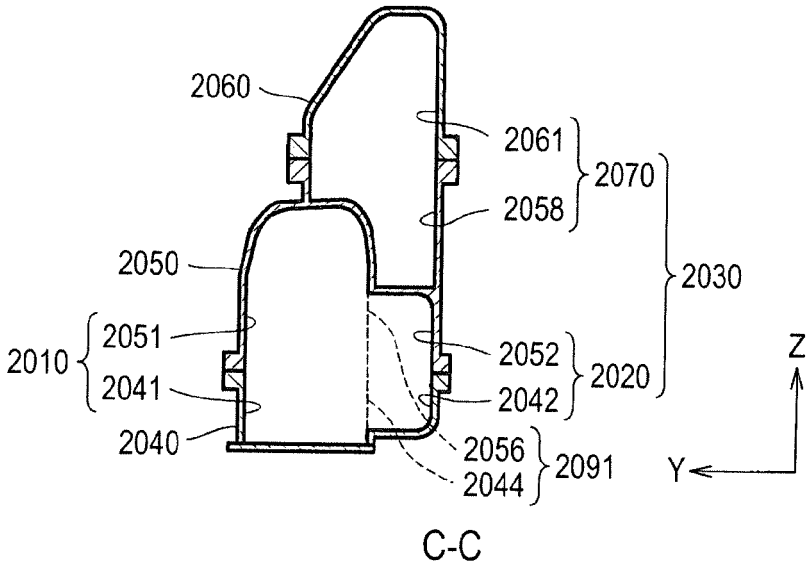
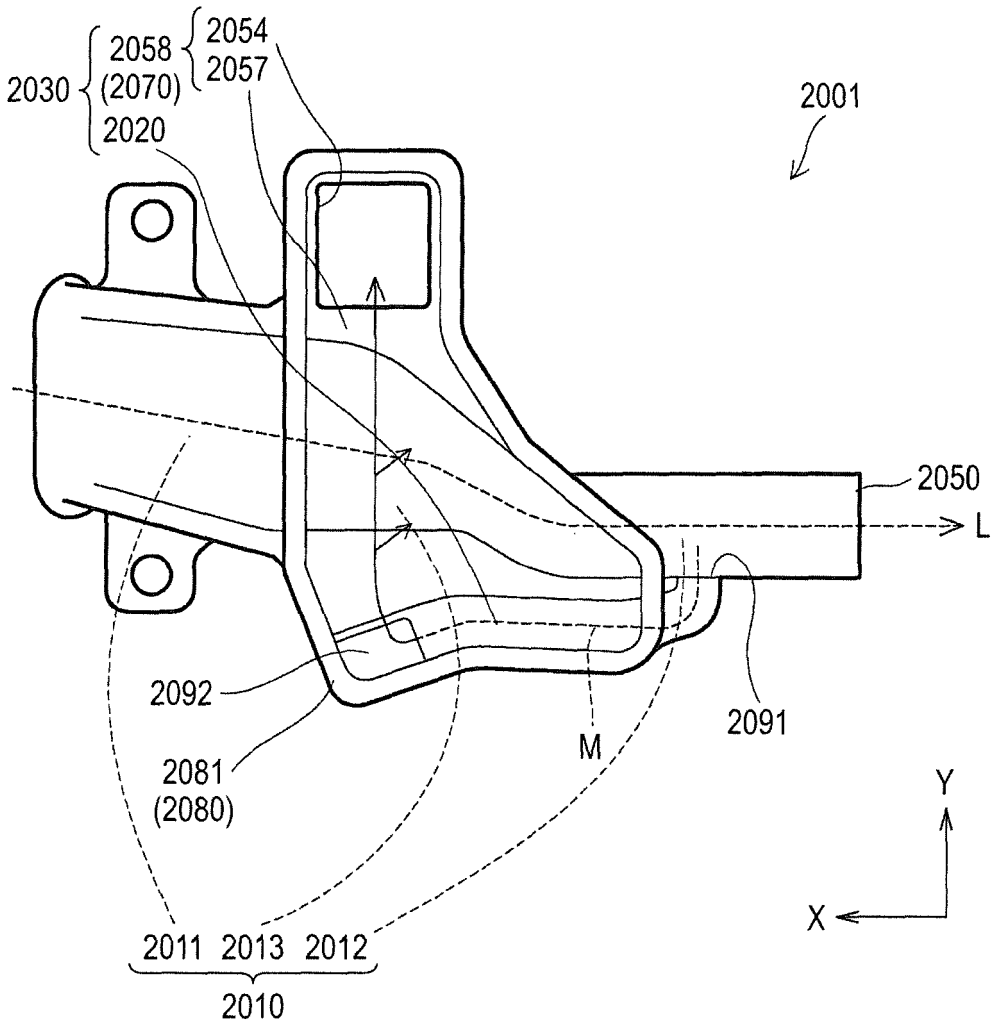


FIG. 15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2020
2054
2057
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2092
2081
(2080)
M
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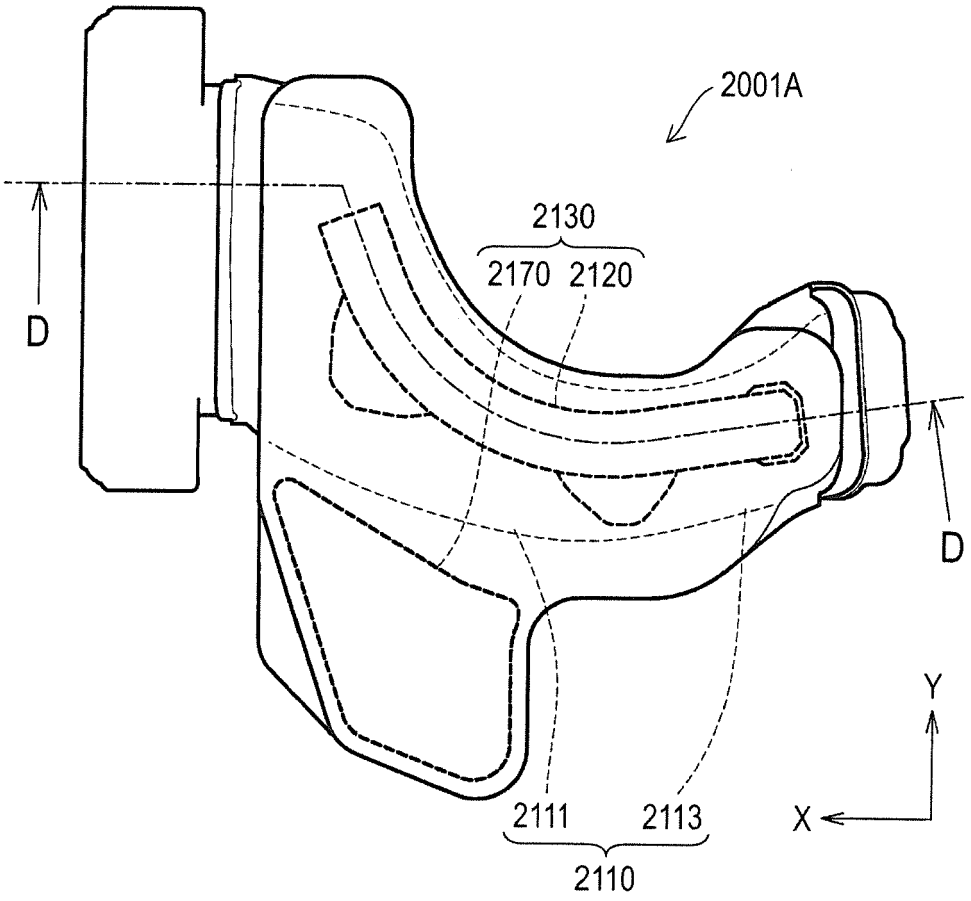
Y
X
2011
2013
2012
2010

FIG. 16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2110

FIG. 17

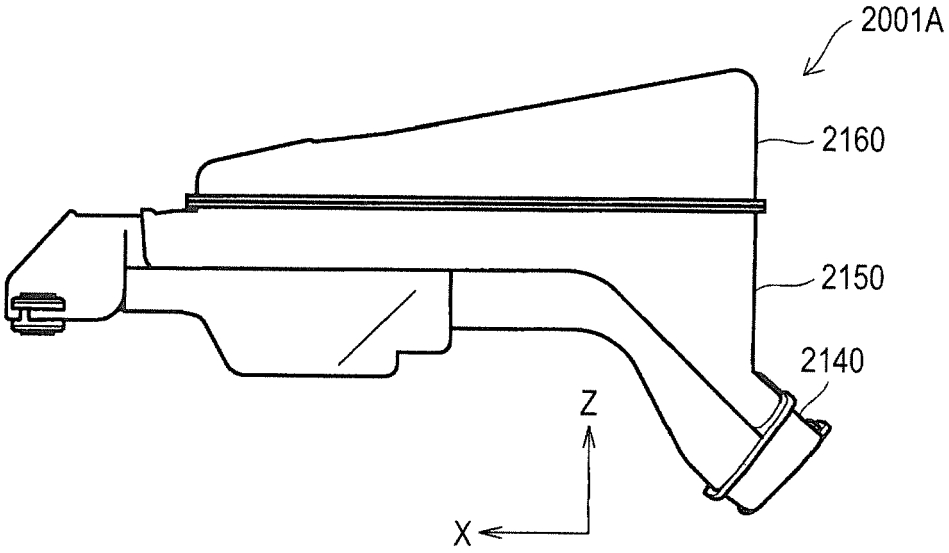
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FIG. 18

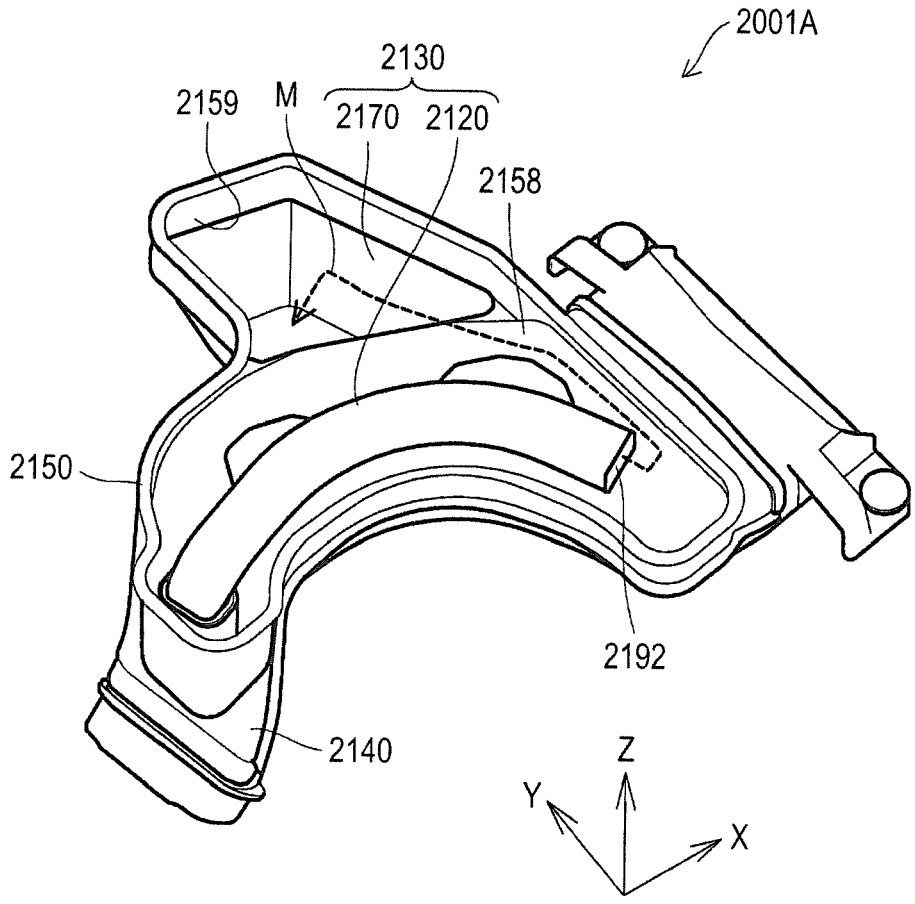
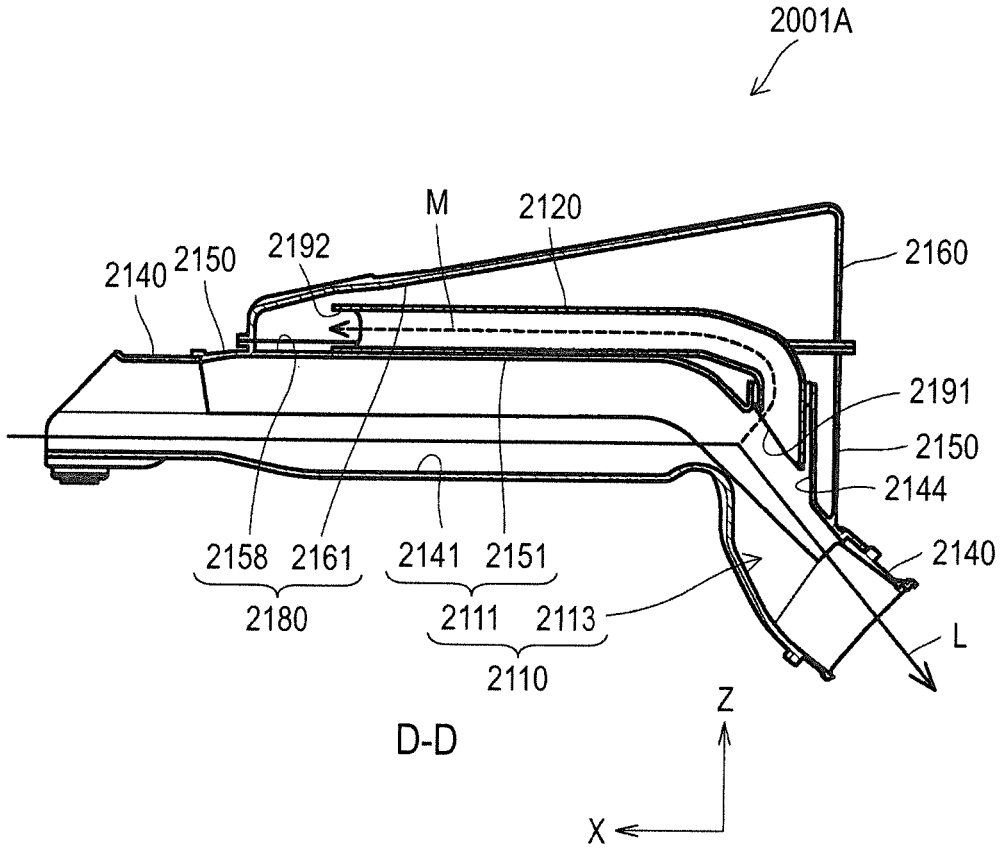


FIG. 19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2161
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2151
2180
2111
2113
2110
L
D-D
Z
X

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 3923198 B **[0002] [0003]**
- JP 9112365 A **[0002]**