

(19)



(11)

EP 1 840 342 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:

03.10.2007 Bulletin 2007/40

(51) Int Cl.:

F01N 1/00 (2006.01)

F01N 1/04 (2006.01)

F01N 1/10 (2006.01)

F01N 7/08 (2006.01)

F01N 7/18 (2006.01)

(21) Application number: **07251315.3**

(22) Date of filing: **28.03.2007**

(84) Designated Contracting States:

**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE
SI SK TR**

Designated Extension States:

AL BA HR MK YU

(30) Priority: **29.03.2006 JP 2006092334**

09.02.2007 JP 2007031097

(71) Applicant: **YAMAHA HATSUDOKI KABUSHIKI
KAISHA**

Iwata-shi, Shizuoka-ken 438-8501 (JP)

(72) Inventors:

- **Sakurai, Taisuke**
Iwata-shi
Shizuoka-ken 438-8501 (JP)
- **Hagiwara, Itsurou**
Iwata-shi
Shizuoka-ken 438-8501 (JP)

(74) Representative: **Harris, Ian Richard et al**

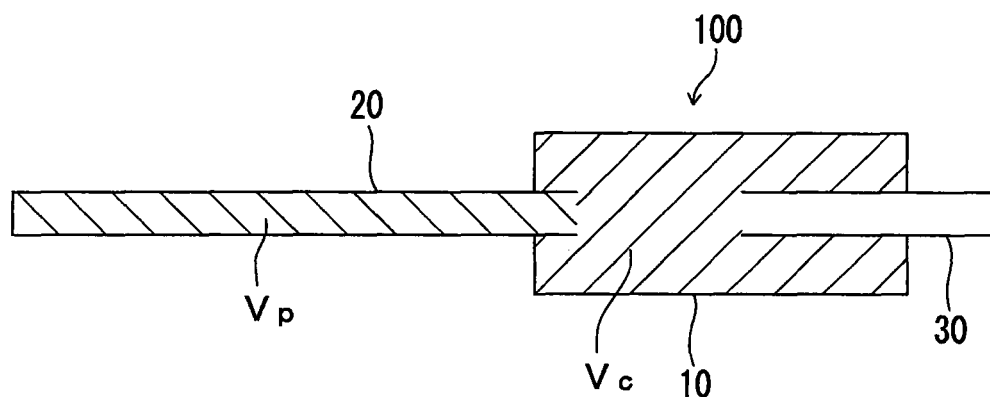
D Young & Co
120 Holborn
London EC1N 2DY (GB)

(54) **Exhaust apparatus for straddle-type vehicles and straddle-type vehicle**

(57) An exhaust apparatus, for a straddle-type vehicle, having an engine (50), the exhaust apparatus (100) including an exhaust pipe (20) connected to the engine (50) and a silencer (10). The volume (V_p) of the exhaust

pipe (20) and the volume (V_c) of the silencer (10) are substantially equal to each other. This allows the provision of an exhaust apparatus which is of reduced size and weight while providing a noise absorption characteristic.

[Fig. 3]



EP 1 840 342 A1

Description

BACKGROUND

5 **[0001]** The present invention relates to an exhaust apparatus (or exhaust device) for a straddle-type vehicle and a straddle-type vehicle.

[0002] A muffler (exhaust apparatus) used in a straddle-type vehicle (for example, a motorcycle) is requested to meet two demands, that is, an exhaust efficiency, at which exhaust gases discharged from an engine should be efficiently discharged, and noise reduction or noise elimination of exhaust noise, which accompanies discharge of exhaust gases

10 of high pressure and high temperature.
[0003] In particular, a demand for noise reduction or noise elimination is put forward in these days when regulations of noise are being made rigorous. Accordingly, it is increasingly desired that noise reduction or noise elimination be attained with an exhaust efficiency maintained. Mufflers for motorcycles are disclosed in, for example, JP-A-8-312324 and JP-A-2003-184541.

15 **[0004]** When design of a muffler is thought only in terms of exhaust efficiency, a muffler (exhaust system) is preferably extended straight. However, such muffler is not accommodated in a vehicle body of a motorcycle. Accordingly, in order to lessen an exhaust resistance, a muffler is extended toward the rear of a vehicle body so as not to be bent suddenly as far as possible, which is actually difficult in many cases because of association with a front wheel and a bank angle. Normally, a muffler having an ideal length in terms of engine performance is in small cases accommodated intact in a configuration of a motorcycle, and as compared with design of a muffler for four-wheel passenger cars, much troubles

20 are involved in designing a muffler, a length of which is nearly best in performance, so as to accommodate the same in a configuration of a motorcycle while maintaining a configuration as smooth as possible.
[0005] Also, not only an exhaust efficiency but also a weight of a muffler has a great influence on controllability in motorcycles. That is, since a motorcycle is light in weight, even a weight of around 1 kg has a great influence on the motorcycle and a distant position of a center of gravity of a muffler in addition to a weight of the muffler has an adverse influence on controllability of the motorcycle.

25 **[0006]** On the other hand, in spite of any contrivance on a construction, a muffler volume is needed to some extent in heightening a noise eliminating effect. In order to conform to regulations on noise, which are increasingly made rigorous, a muffler cannot but be made large in many cases. Besides, when a metallic sheet, of which a muffler is made, is thin, it vibrates to increase noise, so that the muffler is by all means liable to be made large in weight. An increase in muffler weight will worsen controllability of a motorcycle.

30 **[0007]** While an exhaust apparatus for a motorcycle can be designed (muffler design) under various restrictions, typically a noise reducing effect cannot be produced unless a muffler is increased in volume, whereby it is not possible to avoid a phenomenon, in which an increase in volume of a muffler brings about a decrease in controllability of a motorcycle. In a muffler in, for example, present four-stroke motocross motorcycles (in particular, sports vehicles), a silencer is typically increased in volume in order to meet noise reduction and running performance, so that the muffler is large and heavy. Current noise regulations are such that current mufflers cannot be made small and light without disregarding noise factors.

35 **[0008]** Under such situation, the inventors of the present invention have tried to realize an exhaust apparatus (muffler), which is small-sized and light while meeting a running performance (exhaust property) and a noise characteristic.

[0009] In this manner, since a structure of a muffler for motorcycles is determined in terms of a variety of reciprocal factors, it has been extremely difficult to realize a muffler, in which reduction in size and weight is achieved and an exhaust efficiency and a noise absorption characteristic are met.

40 **[0010]** The invention seeks to provide a muffler for straddle-type vehicles, in which reduction in size and weight may be achieved while a demand for a noise absorbing characteristic may be met.

SUMMARY

50 **[0011]** Aspects of the invention are specified in the claims. The features of the claims may be combined in combinations other than those specifically set out in the claims.

[0012] An embodiment of the invention can provide an exhaust apparatus (an exhaust device) for a straddle-type vehicle comprising an engine, the exhaust apparatus comprising an exhaust pipe for connection to the engine and a silencer connected to the exhaust pipe, wherein a volume of the exhaust pipe and a volume of the silencer are substantially equal to each other.

55 **[0013]** In an embodiment, the exhaust pipe is connected to the engine.

[0014] In an embodiment, the exhaust apparatus comprises damping means for an improvement of a damping characteristic in a low frequency range, and a volume of the exhaust pipe and a volume of the silencer are substantially equal to each other to thereby realize the damping means.

[0015] In embodiments of the invention, the ratio of the volume of the silencer to the volume of the exhaust pipe is less than 2 for example in the range 1.4 to 0.7 or 1.2 to 0.7.

[0016] An embodiment has a feature in that the damping means decreases a level of a primary resonance frequency of an exhaust pipe length of the exhaust pipe in the exhaust apparatus.

[0017] In an embodiment, the exhaust apparatus includes a tail pipe connected to the silencer, and the volume of the silencer is a volume obtained by subtracting a volume occupied therein by the exhaust pipe and the tail pipe from an inner volume of the silencer.

[0018] In an embodiment, the volume of the exhaust pipe also includes a volume of a cylinder head exhaust port portion.

[0019] In an embodiment, a ratio of the volume of the silencer to the volume of the exhaust pipe is in the range of 1.4 to 0.7.

[0020] In an embodiment, the silencer comprises an outer cylinder and an inner cylinder accommodated in the outer cylinder, and a punched hole is formed in at least a part of the inner cylinder of the silencer.

[0021] In an embodiment, a sound absorbing material is filled between an inner wall of the outer cylinder and an outer wall of the inner cylinder in the silencer.

[0022] In an embodiment, the exhaust apparatus includes a tail pipe connected to the silencer, and the tail pipe is offset relative to the exhaust pipe radially of the silencer.

[0023] In an embodiment, the sound absorbing material comprises at least one of glass wool and stainless steel wool.

[0024] An embodiment has a feature in that the exhaust apparatus includes a tail pipe connected to the silencer, the silencer comprises an outer cylinder and an inner cylinder accommodated in the outer cylinder, and an outside diameter of the tail pipe is smaller than an inside diameter of the inner cylinder of the silencer.

[0025] An embodiment has a feature in that the inside diameter of the inner cylinder is gradually decreased up to a front end of the tail pipe.

[0026] In an embodiment, an air layer is provided between the tail pipe and the inner cylinder.

[0027] In an embodiment, the silencer comprises an outer cylinder and an inner cylinder accommodated in the outer cylinder, a sound absorbing material is filled between an inner wall of the outer cylinder and an outer wall of the inner cylinder in the silencer, and a first air layer is provided between the inner wall of the outer cylinder and an outer wall of the sound absorbing material.

[0028] In an embodiment, the exhaust apparatus includes a tail pipe connected to the silencer, a second air layer is provided between the tail pipe and the inner cylinder, and the sound absorbing material is arranged between the second air layer provided between the tail pipe and the inner cylinder, and the first air layer provided between the inner wall of the outer cylinder and the outer wall of the sound absorbing material.

[0029] In an embodiment, a chamber is provided in the exhaust pipe, and a volume of the exhaust pipe also includes a volume of the chamber.

[0030] In an embodiment, a hollow conical structure, for example a cone, which maybe a punched cone, is provided in the silencer. The conical structure may be in the form of a cone with a tip end thereof opened and formed with a hole.

[0031] In an embodiment, the silencer comprises an outer cylinder and an inner cylinder accommodated in the outer cylinder, a tail pipe is connected to the inner cylinder of the silencer, and the cone is provided at an upstream end of the tail pipe.

[0032] An embodiment has a feature in that an opening hole of the cone has an opening diameter at an upstream end thereof, which is smaller than an opening diameter at a downstream end thereof.

[0033] In an embodiment, the exhaust apparatus includes a tail pipe connected to the silencer, the silencer comprises an inner cylinder and an outer cylinder, and the conical structure includes a first cone connected to the tail pipe, and a second cone, which covers the first cone and is connected to the inner cylinder.

[0034] An assembly can be provided that includes an engine and the exhaust apparatus.

[0035] A straddle-type vehicle according to the invention comprises a straddle-type vehicle provided with such an assembly.

[0036] In an embodiment, the straddle-type vehicle comprises a four-stroke engine.

[0037] In an embodiment, the straddle-type vehicle comprises an off road type motorcycle.

[0038] Since a volume of the exhaust pipe and a volume of the silencer are made substantially equal to each other, it is possible to improve the damping characteristic of the exhaust apparatus in a low frequency range (in particular, a primary resonance frequency of an exhaust pipe length of the exhaust pipe in the exhaust apparatus) whereby it is possible to achieve a decrease in noise value. Since an improvement in damping characteristic can be achieved by making a volume of the exhaust pipe and a volume of the silencer close to each other instead of an increase in volume of the exhaust apparatus, it is possible to avoid an increase in weight of the exhaust apparatus, so that it is possible to realize a small-sized exhaust apparatus for a straddle-type vehicle. As a result, it is possible to improve a motorcycle in controllability or kinematical performance.

BRIEF DESCRIPTION OF THE DRAWINGS

[0039] Embodiments of the invention are described, by way of example only, with reference to the accompanying drawings.

[0040] Fig. 1 is a side view showing a motorcycle comprising a muffler according to an embodiment of the invention.

[0041] Fig. 2(a) is a perspective view showing the muffler according to the embodiment of the invention, Fig. 2(b) is a view schematically showing an engine 50, and Fig. 2(c) is a perspective view showing a muffler including a chamber 21.

[0042] Fig. 3 is a view schematically showing the structure of the muffler according to the embodiment of the invention.

[0043] Figs. 4(a) and 4(b) are perspective views showing the structures of the muffler according to the embodiment of the invention and a muffler of a comparative example.

[0044] Fig. 5 is a graph making a comparison in damping characteristic between the muffler (Embodiment 1 and Embodiment 2) according to the embodiment of the invention and the muffler of the comparative example.

[0045] Figs. 6(a) to 6(c) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0046] Figs. 7(a) and 7(b) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0047] Figs. 8(a) to 8(c) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0048] Figs. 9(a) and 9(b) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0049] Figs. 10(a) to 10(c) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0050] Figs. 11(a) to 11(c) are cross sectional views schematically showing examples of the muffler according to the embodiment of the invention.

[0051] Fig. 12 is a side view showing a motorcycle comprising the muffler of the comparative example.

DESCRIPTION OF EMBODIMENTS

[0052] Embodiments of the invention will be described below, by way of example, with reference to the drawings. The invention is not limited to the following embodiments.

[0053] Fig. 1 shows a motorcycle 1000, on which an exhaust apparatus according to an embodiment of the invention is mounted. The exhaust apparatus 100 is connected to an engine 50. The exhaust apparatus 100 includes an exhaust pipe 20 and a silencer 10. In addition, the exhaust apparatus 100 includes the silencer 10 is in some cases referred to as "muffler" in the specification of the present application for the sake of convenience.

[0054] The muffler 100 according to the embodiment includes the exhaust pipe 20 connected to the engine 50 of the motorcycle 1000, and the silencer 10 connected to the exhaust pipe 20. With a construction shown in Fig. 1, a tail pipe 30 is connected to the silencer 10.

[0055] A state, in which the muffler 100 according to the embodiment is removed from the motorcycle 1000, is shown in Fig. 2(a). The exhaust pipe 20 and the silencer 10 of the muffler 100 shown in Fig. 2(a) are formed with members for mounting to a vehicle body. The muffler 100 according to the embodiment is one for four-stroke engines and the motorcycle 1000 shown in Fig. 1 is an off road vehicle. In addition, in the exhaust pipe 20 shown in Fig. 2(a), its end connected to the engine 50 mounts thereto a cylinder head exhaust port portion 22.

[0056] The exhaust pipe 20 connects to an exhaust hole of the engine 50 as shown in Fig. 2 (b) to lead exhaust gases from the engine 50 to the silencer 10. In an example as shown, the cylinder head exhaust port portion 22 of the exhaust pipe 20 is connected to the engine 50. The silencer 10 has a noise eliminating function to discharge exhaust gases led from the exhaust pipe 20 outside. In the case where the tail pipe 30 is connected to the silencer 10, exhaust gases are discharged outside from the tail pipe 30. In addition, a chamber 21 can be further provided in the exhaust pipe 20 as shown in Fig. 2(c). In this case, exhaust gases from the engine 50 are once expanded in the chamber 21 and then led to the silencer 10 to be discharged outside.

[0057] Fig. 3 schematically shows the structure of the muffler 100 according to the embodiment. The muffler 100 according to the embodiment is structured such that a volume (V_p) of the exhaust pipe 20 is substantially equal to a volume (V_c) of the silencer 10.

[0058] Here, the volume (V_c) of the silencer 10 is a volume obtained by subtracting a volume occupied therein by the exhaust pipe 20 from an interior of the silencer 10. Also, in the case where the tail pipe 30 is connected to the silencer 10, the volume (V_c) of the silencer 10 is a volume obtained by subtracting a volume occupied therein by the exhaust pipe 20 and the tail pipe 30 from an interior of the silencer 10. Also, in the case where the chamber 21 is formed in the exhaust pipe 20, a volume of the chamber 21 constitutes a part of a volume occupied by the exhaust pipe 20 and a volume (V_h) of the cylinder head exhaust port portion 22 also constitutes a part of a volume occupied by the exhaust

pipe 20.

[0059] Since the muffler 100 according to the embodiment is structured so that the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are made substantially equal to each other, it is possible to improve a damping characteristic of a low frequency range of the muffler 100, in particular, a primary resonance frequency f_1 (More specifically, a primary resonance frequency f_1 of an exhaust pipe length of the exhaust pipe 20; referred below in some cases to as "a primary resonance frequency f_1 of a muffler" for convenience' sake). When a noise value in a low frequency range is decreased, sound waves having a large energy can be reduced in volume, so that the noise value can be decreased only by damping a noise value of a primary resonance frequency (f_1) of the muffler (Specifically, damping can be achieved until regulations can be met).

[0060] With the construction of the embodiment, an improvement in damping characteristic can be achieved by making the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 close to each other instead of an increase in muffler volume, so that it is possible to avoid an increase in muffler weight. That is, the muffler 100 according to the embodiment includes damping means for an improvement in damping characteristic in a low frequency range (in particular, a primary resonance frequency f_1) and the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are made substantially equal to each other to thereby realize the damping means, so that it is not necessary to make the muffler 100 larger in volume than needed and there is no need for any separately independent, new member as damping means, thus enabling realizing a small-sized muffler 100.

[0061] As a specific example, the structure of the muffler 100 according to the embodiment will be described with reference to Fig. 4. Fig. 4(a) shows a muffler 100 having a structure according to the embodiment and Fig. 4(b) shows a muffler 200 as a comparative example.

[0062] Exhaust pipes 20 and 20A shown in Figs. 4(a) and 4(b) are substantially equal to each other in volume but silencers 10 and 10A are considerably different in volume from each other.

[0063] The silencer 10A shown in Fig. 4(b) has a considerably larger volume than that of the exhaust pipe 20A according to a typical design technique in order to obtain a favorable noise eliminating characteristic (damping characteristic). Specifically, the volume of the silencer 10A exceeds twice the volume of the exhaust pipe 20A, and more specifically, is about 2.5 times the latter.

[0064] On the other hand, the silencer 10 shown in Fig. 4(a) has a volume near to the volume of the exhaust pipe 20 contrary to the typical design technique. Specifically, the volume of the silencer 10 is nearly 1.4 times or less the volume of the exhaust pipe 20. More specifically, it is desired that the volume of the silencer 10 be in the range of 1.2 to 0.7 times the volume of the exhaust pipe 20.

[0065] Making a comparison in weight between the both, the weight of the silencer 10 amounts only to around 60 % of the weight of the silencer 10A. A decrease in weight of the silencer 10 not only produces an effect of a decrease in total weight of the motorcycle 1000 but contributes much to an improvement in controllability of the motorcycle 1000 since a member or members positioned distant from a vehicle body center (or, a center of gravity of a vehicle body) of the motorcycle 1000 can be reduced in weight.

[0066] Fig. 12 shows a construction, in which the muffler 200 of a comparative example shown in Fig. 4(b) is mounted to a motorcycle. Making a comparison between both a motorcycle 2000 shown in Fig. 12 and the motorcycle 1000, according to the embodiment, shown in Fig. 1, it is possible to understand how small the muffler becomes in size and volume. As described above, a technical meaning that a small-sized and lightweight muffler 100 could be developed in that situation, in which a muffler cannot but be increased in volume in a typical muffler design in order to obtain a favorable noise eliminating characteristic, is very great.

[0067] Also, while being described later, the muffler 100 according to the embodiment can decrease a noise value further than the muffler 200, which is large in muffler volume. This demonstrates in double meaning that the muffler 100 according to the embodiment has an excellent, technical meaning.

[0068] Fig. 5 is a graph illustrating damping characteristics of the muffler 100 according to the embodiment and the muffler 200 of the comparative example. The damping characteristic of the muffler 100 according to the embodiment is indicated by plots in Embodiment 1 and Embodiment 2 while the damping characteristic of the muffler 200 is indicated by plots in the comparative example.

[0069] In a low frequency range, Embodiment 1, Embodiment 2 and the comparative example are substantially the same in a damping characteristic of f_0 (damping level (dB)) but it is found that Embodiment 1 and Embodiment 2 are favorable in a damping characteristic (damping level (dB)) of f_1 (primary resonance frequency of an exhaust pipe length of the exhaust pipe in the exhaust apparatus) as compared with the comparative example. In other words, Embodiment 1 and Embodiment 2 are low in noise value of f_1 as compared with the comparative example. The reason why the noise value of f_1 is small in Embodiment 1 and Embodiment 2 is that the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are substantially equal to each other.

[0070] With that construction, in which the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are made substantially equal to each other, the reason why the noise value in a low frequency range (in particular, f_1) can be decreased is as follows. If a muffler were composed of only the exhaust pipe 20 (without the silencer 10), f_1

would be a resonance frequency of 1/4 wavelength determined by an exhaust pipe length and be suddenly changed into a resonance frequency, at which the both parts (20, 10) were coupled together, in a configuration, in which the silencer 10 were added to the exhaust pipe 20. Here, a strongest coupled state corresponds to the case where the both parts (20, 10) are equal to each other in resonance frequency, which means in other acoustic words that the both parts are equal to each other in volume, and when a sound absorbing material is filled in one of them in this state, it is possible to efficiently damp the frequency.

[0071] Also, when the resonance frequency f_1 is to be decreased, volumes (V_p , V_c) of the exhaust pipe 20 and the silencer 10 are influenced thereby, but even when the exhaust pipe 20 is bent, there is caused no substantial influence, which provides an advantage in design.

[0072] In addition, as described above, even in the case where, for example, the chamber 21 is provided on the exhaust pipe 20 and a part of the exhaust pipe 20 is bulged, a design will do, in which the volume (V_p) of the exhaust pipe 20 includes a volume of the chamber 21 and the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 are made close to each other. In addition, the same is also the case with a volume of the cylinder head exhaust port portion 22.

[0073] In addition, a frequency f_0 (Hz) generated by resonance of the whole muffler can be found by, for example, the following formula in the construction shown in Fig. 3.

$$f_0 = (c/2\pi) \cdot \{S/(V \cdot L)\}^{1/2} \dots (\text{Formula})$$

[0074] Here, "c" indicates a velocity of sound, "V" indicates an exhaust system volume (that is, " $V_p + V_c$ "), "L" indicates a length of the tail pipe 30, and "S" indicates a cross sectional area of the tail pipe 30.

[0075] When a ratio of the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 is ideally made 1:1 in the graph of damping characteristic shown in Fig. 5, the noise value of f_1 in Embodiment 1 and Embodiment 2 can be further damped.

[0076] Since the exhaust pipe 20 is actually formed as shown in, for example, Fig. 4 to be bent in order to meet various design conditions and the size and weight of the silencer 10 is also determined in conformity to other conditions (vehicle body weight, vehicle body balance, etc.), however, it is unnecessary in many cases to stick the ratio of the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 to an ideal 1:1 provided that an effect of a decrease in noise value is produced. That is, provided that a desired effect of a decrease in noise value is produced by making the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 close to each other contrary to a technical thought (for example, $V_c/V_p > 2$) that it is desirable in a typical muffler design to make the silencer 10 large in volume, it is possible to change a design of the exhaust pipe 20 and the silencer 10 in that range, in which such effect is produced (as an example, 1.2 times to 0.7 times).

[0077] In the graph shown in Fig. 5, it is found that the damping characteristic of the muffler in Embodiment 1 and Embodiment 2 is favorable (that is, noise can be decreased) in a low frequency range (for example, in the order of 600 to 800 Hz), and the comparative example demonstrates a favorable damping characteristic in a frequency range therebeyond. Accordingly, with the muffler 100 according to the embodiment of the invention, a decrease in noise component in a low frequency range is achieved by damping means (damping means for an improvement of a damping characteristic in a low frequency range), which is realized by making the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 substantially equal to each other, and a decrease in noise component in a frequency range therebeyond can also be achieved by other techniques.

[0078] Modifications of the muffler 100 according to the embodiment will be described below with reference to Figs. 6 to 11. The respective figures schematically show a structure of the silencer 10 in the muffler 100 according to the embodiment, (a) being lateral, cross sectional views, and (b) being cross sectional views as viewed from the rear of a vehicle body. In addition, (c) are partially enlarged views in (a).

[0079] The silencer 10 shown in Fig. 6 comprises an outer cylinder 10a and an inner cylinder 10b accommodated in the outer cylinder 10a. Punched holes 13 are formed in at least a part (region P) of the inner cylinder 10b of the silencer 10.

[0080] The punched holes 13 are small holes formed in the silencer 10 (here, the inner cylinder 10b) and serve to enable energy of exhaust gases, which are introduced from the exhaust pipe 20, to be led to the outer cylinder 10a through the small holes. In an example shown in Fig. 6, a sound absorbing material 15 is filled in a manner to come into close contact between an inner wall of the outer cylinder 10a and an outer wall of the inner cylinder 10b.

[0081] The sound absorbing material 15 is a material capable of absorbing sound waves and can use, for example, glass wool, stainless steel wool (SUS wool), aluminum wool, ferrite, asbestos, etc. In this example, glass wool is used as the sound absorbing material 15. The sound absorbing material 15 fairly absorbs a high frequency sound but is less effective in low frequency sound, so that a synergistic effect is produced when combined with the construction of the muffler 100 according to the embodiment.

[0082] In this example, a SUS wool 15b is provided on the outer wall of the inner cylinder 10b and a glass wool 15a is provided on an outer periphery thereof. In other words, the SUS wool 15b is provided on the outer wall of the inner cylinder 10b and the glass wool 15a is provided on the inner wall of the outer cylinder 10a. Also, the inner cylinder 10b is gradually decreased in inside diameter up to a front end of the tail pipe 30. With a silencer 10 shown in Fig. 7, an air layer 17 is formed between a tail pipe 30 and an inner cylinder 10b. Specifically, an outside diameter d of the tail pipe 30 is smaller than an inside diameter D of the inner cylinder 10b of the silencer 10. In this example, punched holes (region P) are formed in as far as a region (a region, in which the air layer 17 is positioned), in which the tail pipe 30 is positioned. In addition, a cross sectional structure of the silencer 10 shown in Fig. 7 is substantially the same as that shown in the partially enlarged view of Fig. 6(c).

[0083] The construction shown in this example can incorporate therein a damping characteristic, in which noise elimination is achieved by varying (enlarging) a pipe (cylinder) in cross sectional area, and such combination makes it possible to regulate the damping characteristic of the muffler 100 according to the embodiment. Specifically, the pipe (cylinder) is changed in cross sectional area to enable obtaining a damping characteristic, in which sounds mainly in a low frequency range are eliminated. Also, the provision of the air layer 17 enables producing both effects of noise reduction by the sound absorbing material 15 and noise reduction by pipe bulging.

[0084] The silencer 10 shown in Fig. 8 has a structure similar to that in Fig. 6, but a sound absorbing material 15 is arranged on an outer wall of an inner cylinder 10b and an air layer 19 is present on an inner wall of an outer cylinder 10a, in which no sound absorbing material 15 is filled.

[0085] Here, the sound absorbing material 15 comprises a combination of SUS wool 15b and glass wool 15a in the same manner as that shown in Fig. 6. In addition, as shown in Fig. 8(c), a partition 10c, which supports the sound absorbing material 15 (15a, 15b), is provided and punched holes 13 are formed on the partition 10c.

[0086] With such construction, it is possible to regulate a damping characteristic of the muffler 100 according to the embodiment owing to both effects of noise reduction by the sound absorbing material 15 and noise reduction by pipe bulging.

[0087] A silencer 10 shown in Fig. 9 incorporates a feature of the structure shown in Fig. 7 into the structure shown in Fig. 8 such that an air layer 17 is formed between a tail pipe 30 and an inner cylinder 10b, and such structural feature (that is, a structural feature that the sound absorbing material 15 is arranged between the air layer (first air layer) 19 provided between the inner wall of the outer cylinder 10a and the outer wall of the sound absorbing material 15 and the air layer (second air layer) 17 provided between the tail pipe 30 and the inner cylinder 10b) regulates a damping characteristic of the muffler 100 according to the embodiment. In addition, a cross sectional structure of the silencer 10 shown in Fig. 9 is substantially the same as that shown in the partially enlarged view of Fig. 8(c).

[0088] In addition, the silencer 10 according to the embodiment is not limited to a structure, which comprises the outer cylinder 10a and the inner cylinder 10b accommodated in the outer cylinder 10a, but can adopt a structure shown in Fig. 10. That is, it suffices to design a muffler 100 having a desired damping characteristic by the use of further means, which combines with damping means in a low frequency range, which is realized by making the volume (V_p) of the exhaust pipe 20 and the volume (V_c) of the silencer 10 substantially equal to each other, to enable reinforcing the damping means. Here, the sound absorbing material 15 in Fig. 10(c) comprises, for example, SUS wool, or glass wool, or a combination thereof.

[0089] Also, with a silencer 10 shown in Fig. 10, a tail pipe 30 is offset relative to an exhaust pipe 20 radially of the silencer 10. By doing this, even when an air layer about the exhaust pipe 20 is decreased in cross sectional area by a sound absorbing material 15, such decrease can be compensated for by a cross sectional area of the tail pipe 30.

[0090] A construction, in which a punched cone 32 is arranged in a silencer 10 as shown in, for example, Fig. 11, can be adopted as an example of such further means.

[0091] The punched cone 32 comprises a member, which is in the form of a cone with a tip end thereof opened and formed on a cone-shaped side 35 with punched holes 13, and by which an effect of noise absorption can be produced and a directly transmitting sound of exhaust noise can be decreased. The punched cone 32 has a truncated cone shape.

[0092] An opening hole 37 provided on the punched cone has an opening diameter at an upstream end thereof, which is made smaller than an opening diameter at a downstream end thereof. Thereby, it is possible to prevent direct transmission of noise, thus enabling improving a damping effect. It is possible to arrange one or plural punched cones 32 within the silencer 10. According to the embodiment, the punched cones 32 are provided in two locations (32a, 32b) on the inner cylinder 10b and an upstream end of the tail pipe 30. In addition, it is possible to provide only one punched cone 32 instead of several in number and to provide three or more punched cones.

[0093] In addition, "upstream" side and "downstream" side referred to in the specification of the present application mean an upstream side and a downstream side, respectively, in a direction, in which exhaust gases in the muffler flow. In other words, "upstream" side is that side, on which an engine is arranged, and "downstream" side is that side, on which exhaust gases are discharged outside.

[0094] In the example shown in Fig. 11, the punched cone 32 is provided at an end of the tail pipe 30. Specifically, the punched cone includes a first cone 32a connected to the tail pipe 30 and a second cone 32b, which covers the first

cone 32a and is connected to the inner cylinder 10b. By providing a plurality (32a, 32b) of the punched cones 32, it is possible to improve a damping effect further effectively.

[0095] In addition, while Fig. 1 shows an off road type motorcycle as an example of the motorcycle 1000, the motorcycle 1000 may be an on road type one. Also, "motorcycle" in the specification of the present application means a motorcycle and means a vehicle, which includes a bicycle with a motor (motorbike) and a scooter and can specifically turn with a vehicle body inclined. Accordingly, a three-wheeler/four-wheeler, at least one of a front wheel and a rear wheel of which has two or more wheels and which is three, four (or more) in the number of tires, can be included in "motorcycle". In addition, applicability is not limited to a motorcycle but to other vehicles capable of making use of the effect of the invention, for example, a so-called straddle-type vehicle, which includes a four-wheeled buggy, ATV (All Terrain Vehicle), and a snowmobile, except a motorcycle.

[0096] There has been described an exhaust device for a straddle-type vehicle, comprising an engine, and an exhaust part including an exhaust pipe connected to the engine and a silencer connected to the exhaust pipe, wherein a volume of the exhaust pipe and a volume of the silencer are substantially equal to each other

[0097] While the invention has been described with respect to preferred embodiments, such descriptions are not limitative but various modifications are of course possible.

[0098] According to embodiments of the invention, it is possible to provide a muffler for a straddle-type vehicle, which achieves reduction in size and weight while meeting a demand for a noise absorption characteristic.

DESCRIPTION OF REFERENCE NUMERALS AND SIGNS

[0099]

10: silencer

10a: outer cylinder

10b: inner cylinder

13: punched hole

15: sound absorbing material

17: air layer (second air layer)

19: air layer (first air layer)

20: exhaust pipe

21: chamber

22: cylinder head exhaust port portion

30: tail pipe

32: punched cone

32a: first cone

32b: second cone

50: engine

100: muffler (exhaust apparatus)

200: muffler

1000 motorcycle

Vc: volume of silencer
Vp: volume of exhaust pipe
5 Vh: volume of cylinder head exhaust port portion
d: outside diameter of tail pipe
D: inside diameter of inner cylinder
10

Claims

- 15 1. An exhaust apparatus for a straddle-type vehicle having an engine, the exhaust apparatus comprising
an exhaust pipe to be connected to the engine and a silencer connected to the exhaust pipe,
wherein a volume of the exhaust pipe and a volume of the silencer are substantially equal to each other.
- 20 2. The exhaust apparatus according to claim 1, further comprising damping means for an improvement of a damping
characteristic in a low frequency range,
wherein a volume of the exhaust pipe and a volume of the silencer are substantially equal to each other to thereby
realize the damping means.
- 25 3. The exhaust apparatus according to claim 2, wherein the damping means decreases a level of a primary resonance
frequency of an exhaust pipe length of the exhaust pipe in the exhaust apparatus.
- 30 4. The exhaust apparatus according to claim 2 or claim 3, further including a tail pipe connected to the silencer, and
the volume of the silencer is a volume obtained by subtracting a volume occupied therein by the exhaust pipe
and the tail pipe from an inner volume of the silencer.
- 35 5. The exhaust apparatus according to any of claims 2 to 4, wherein the volume of the exhaust pipe also includes a
volume of a cylinder head exhaust port portion.
- 40 6. The exhaust apparatus according to any of claims 2 to 5, wherein a ratio of the volume of the silencer to the volume
of the exhaust pipe is in the range of 1.4 to 0.7.
- 45 7. The exhaust apparatus according to any preceding claim,
wherein the silencer comprises an outer cylinder and an inner cylinder accommodated in the outer cylinder, and
a hole is formed in at least a part of the inner cylinder of the silencer.
- 50 8. The exhaust apparatus according to any preceding claim,
wherein a sound absorbing material is filled between an inner wall of the outer cylinder and an outer wall of the inner
cylinder in the silencer.
- 55 9. The exhaust apparatus according to claim 8, wherein the sound absorbing material comprises at least one of glass
wool and stainless steel wool.
10. The exhaust apparatus according to any preceding claim, including a tail pipe connected to the silencer, and
the tail pipe is offset relative to the exhaust pipe radially of the silencer.
11. The exhaust apparatus according to any preceding claim, including a tail pipe connected to the silencer,
the silencer comprises an outer cylinder and an inner cylinder accommodated in the outer cylinder, and
an outside diameter of the tail pipe is smaller than an inside diameter of the inner cylinder of the silencer.

12. The exhaust apparatus according to claim 11, wherein the inside diameter of the inner cylinder is gradually decreased up to a front end of the tail pipe.

13. The exhaust apparatus according to claim 11 or claim 12,
wherein an air layer is provided between the tail pipe and the inner cylinder.

14. The exhaust apparatus according to any preceding claim,
wherein the silencer comprises an outer cylinder and

an inner cylinder accommodated in the outer cylinder, and
wherein a sound absorbing material is filled between an inner wall of the outer cylinder and an outer wall of the inner cylinder in the silencer, and
a first air layer is provided between the inner wall of the outer cylinder and an outer wall of the sound absorbing material.

15. The exhaust apparatus according to claim 14, wherein the exhaust apparatus includes a tail pipe connected to the silencer,

a second air layer is provided between the tail pipe and the inner cylinder, and
the sound absorbing material is arranged between the second air layer provided between the tail pipe and the inner cylinder, and the first air layer provided between the inner wall of the outer cylinder and the outer wall of the sound absorbing material.

16. The exhaust apparatus according to any preceding claim,
wherein a chamber is provided in the exhaust pipe, and a volume of the exhaust pipe also includes a volume of the chamber.

17. The exhaust apparatus according to any preceding claim, further comprising a cone, which is provided in the silencer and in the form of a cone with a tip end thereof opened and formed with a hole.

18. The exhaust apparatus according to claim 17, wherein the silencer comprises an outer cylinder and an inner cylinder accommodated in the outer cylinder, and
wherein a tail pipe is connected to the inner cylinder of the silencer, and

the cone is provided at an upstream end of the tail pipe.

19. The exhaust apparatus according to claim 18, wherein an opening hole of the cone has an opening diameter at an upstream end thereof, which is smaller than an opening diameter at a downstream end thereof.

20. The exhaust apparatus according to any of claims 17 to 19, including a tail pipe connected to the silencer,

the cone includes a first cone connected to the tail pipe, and
a second cone, which covers the first cone and is connected to the inner cylinder.

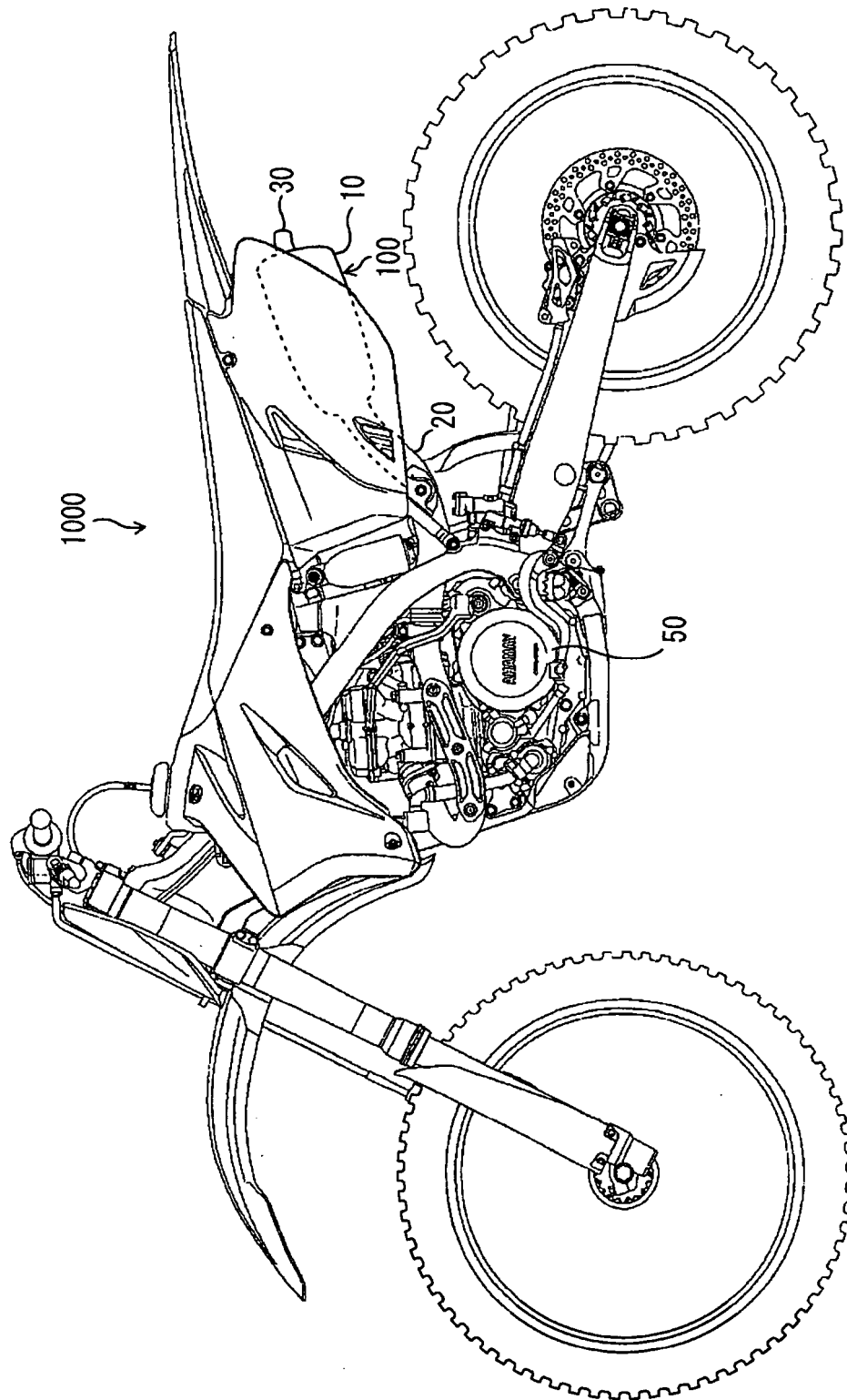
21. An assembly comprising an engine and an exhaust apparatus according to any preceding claim.

22. A straddle-type vehicle comprising an engine and the exhaust apparatus according to any of claims 1 to 20.

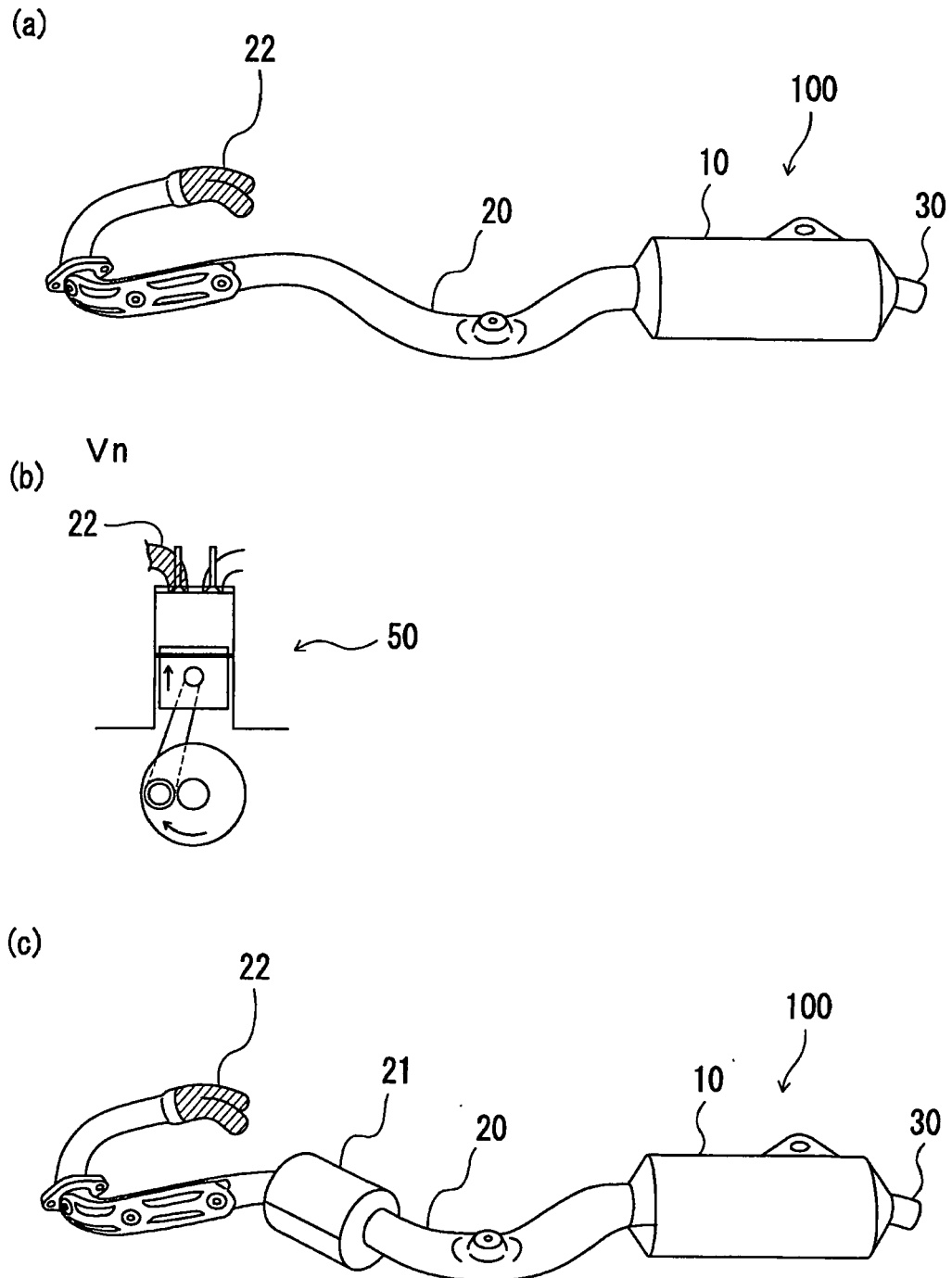
23. The straddle-type vehicle, according to claim 22,
wherein the engine is a four-stroke engine.

24. The straddle-type vehicle, according to claim 22 or claim 23, wherein the straddle type vehicle is an off road type motorcycle.

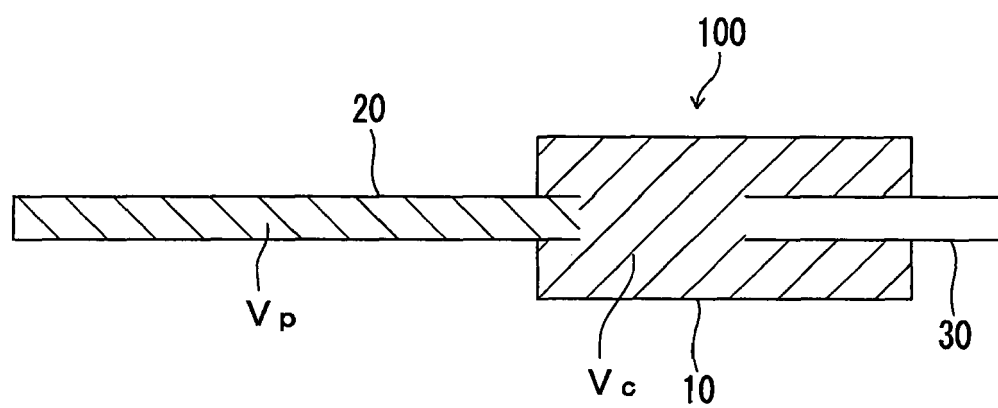
[Fig. 1]



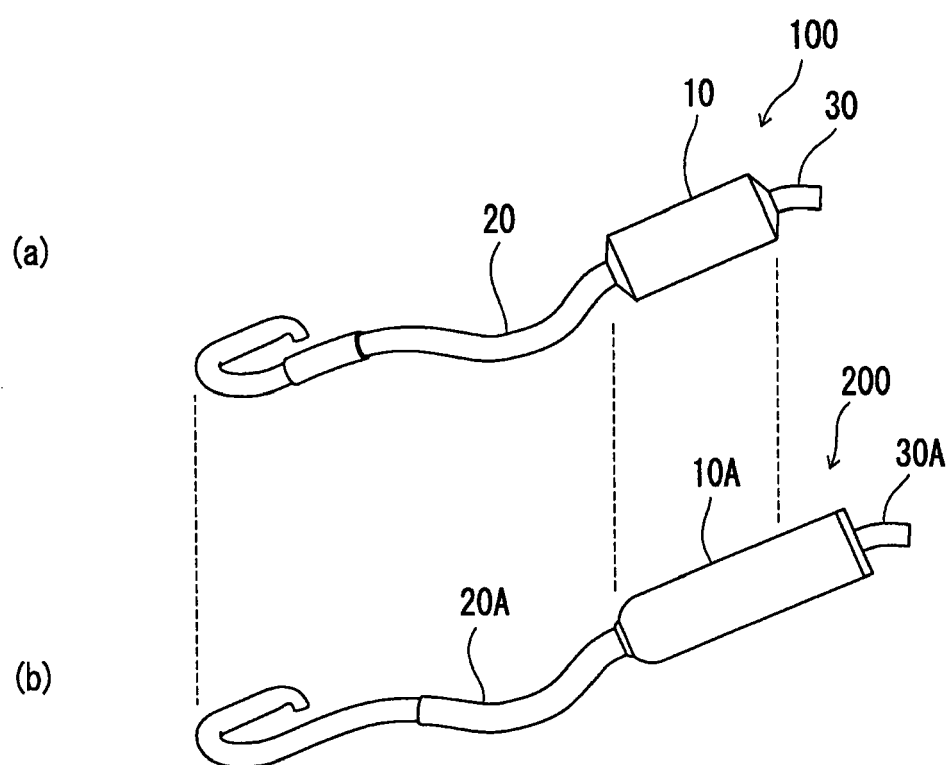
[Fig. 2]



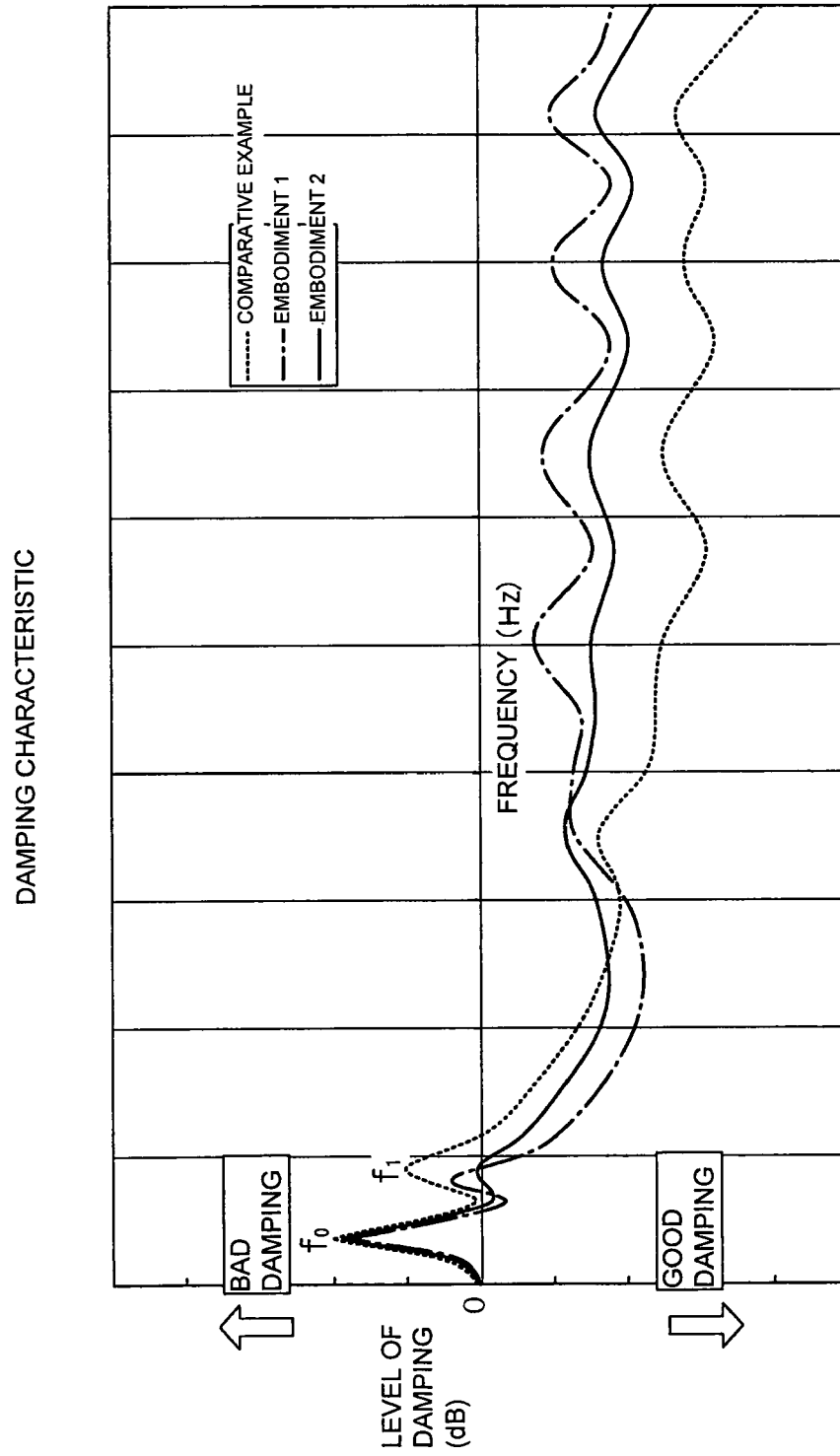
[Fig. 3]



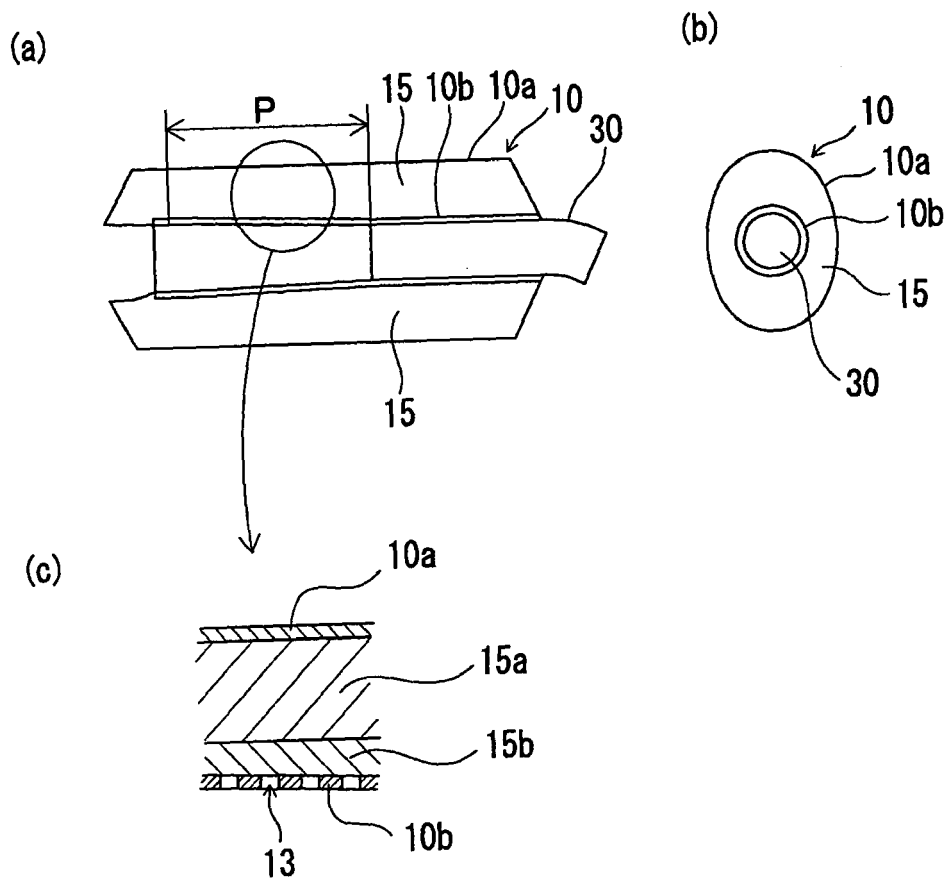
[Fig. 4]



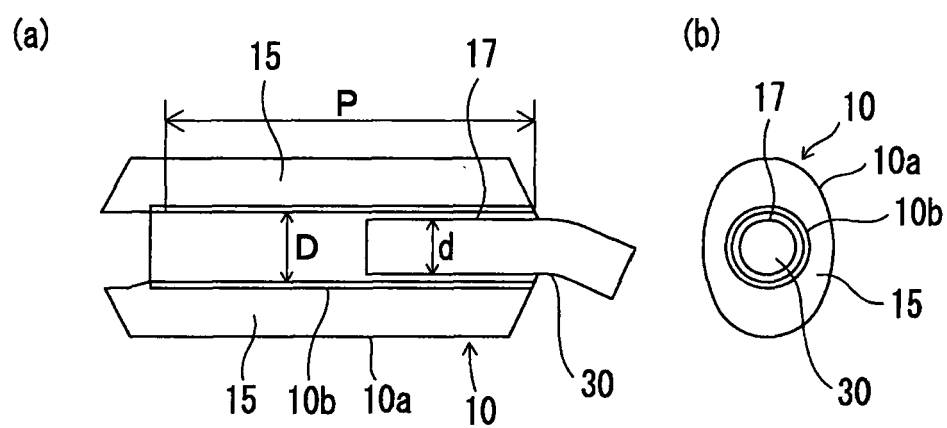
[Fig. 5]



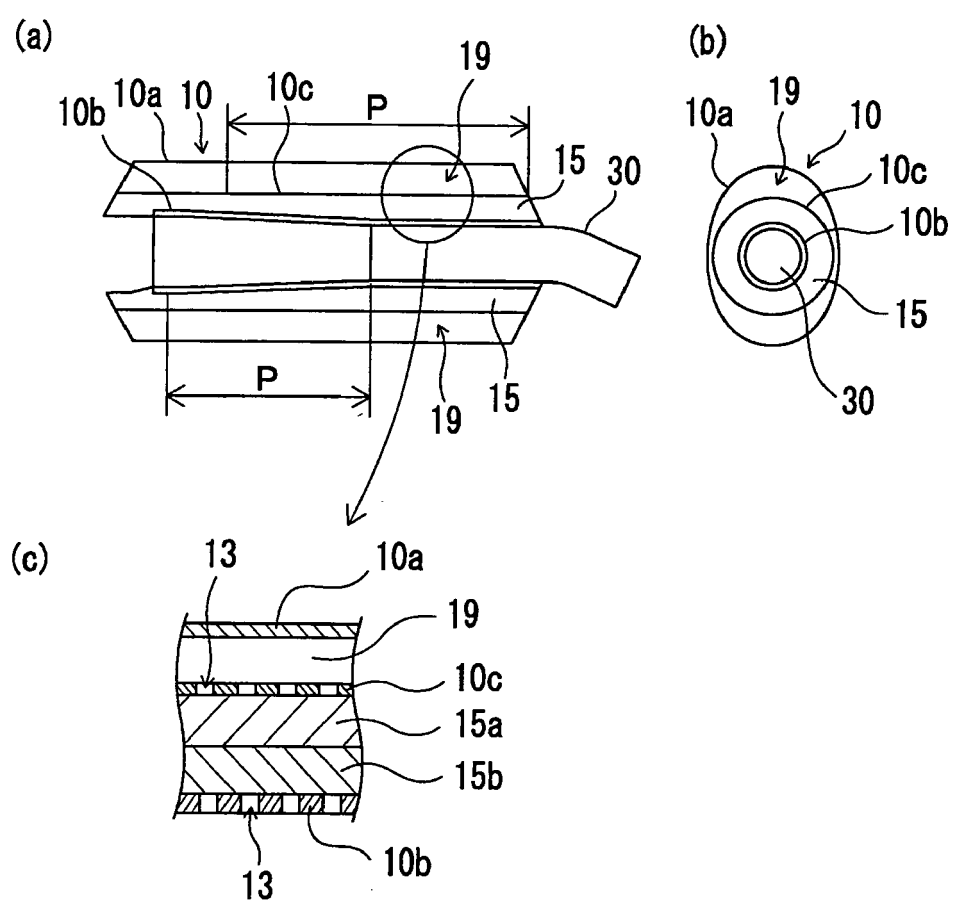
[Fig. 6]



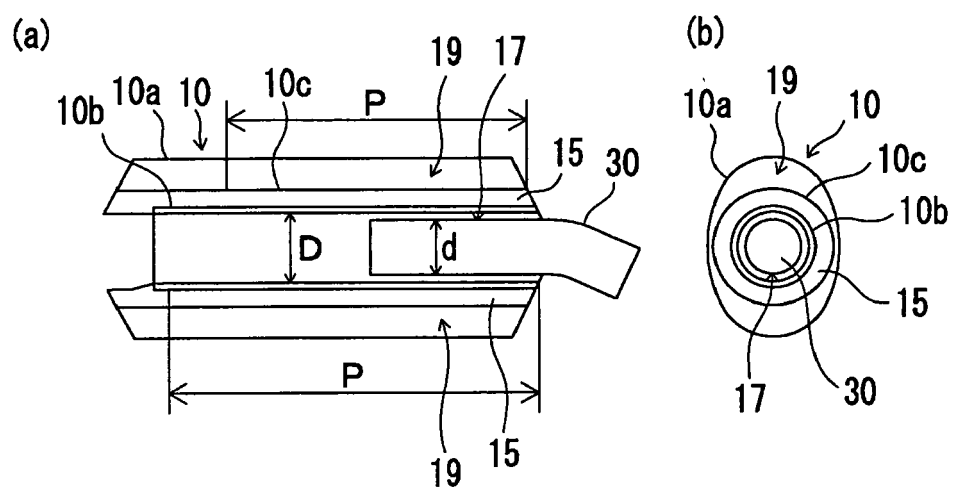
[Fig. 7]



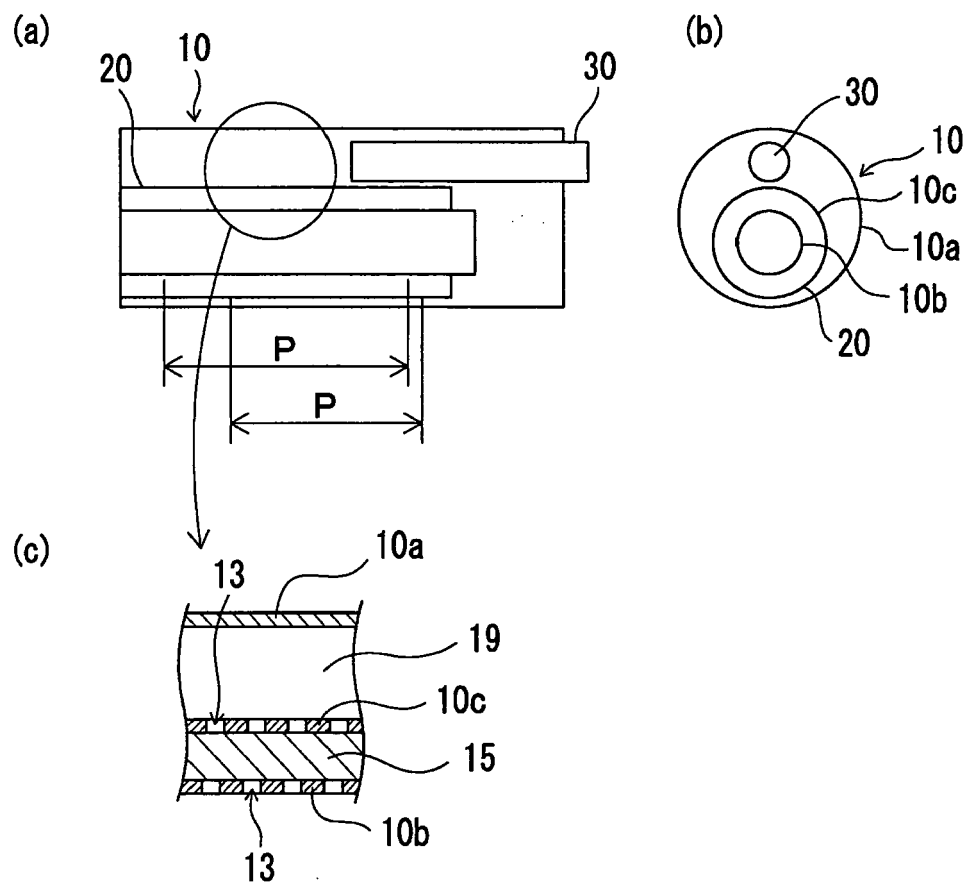
[Fig. 8]



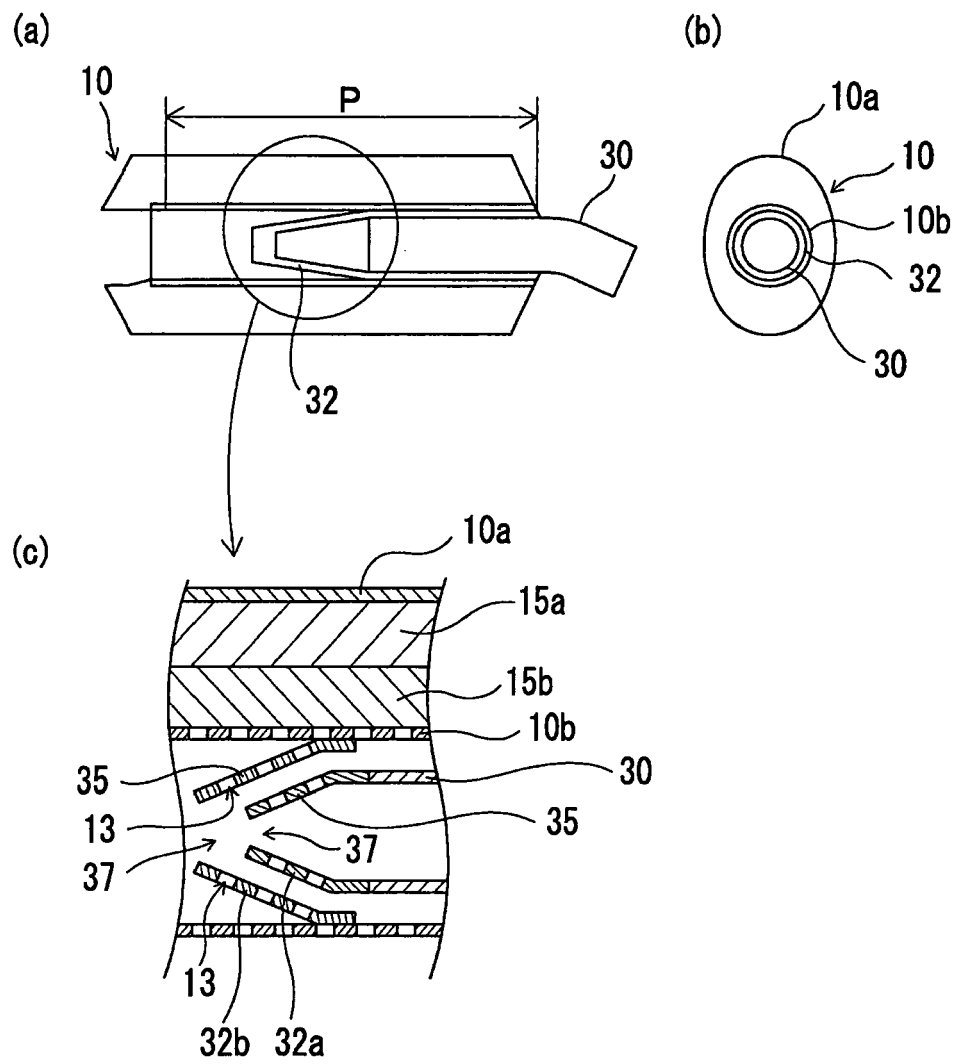
[Fig. 9]



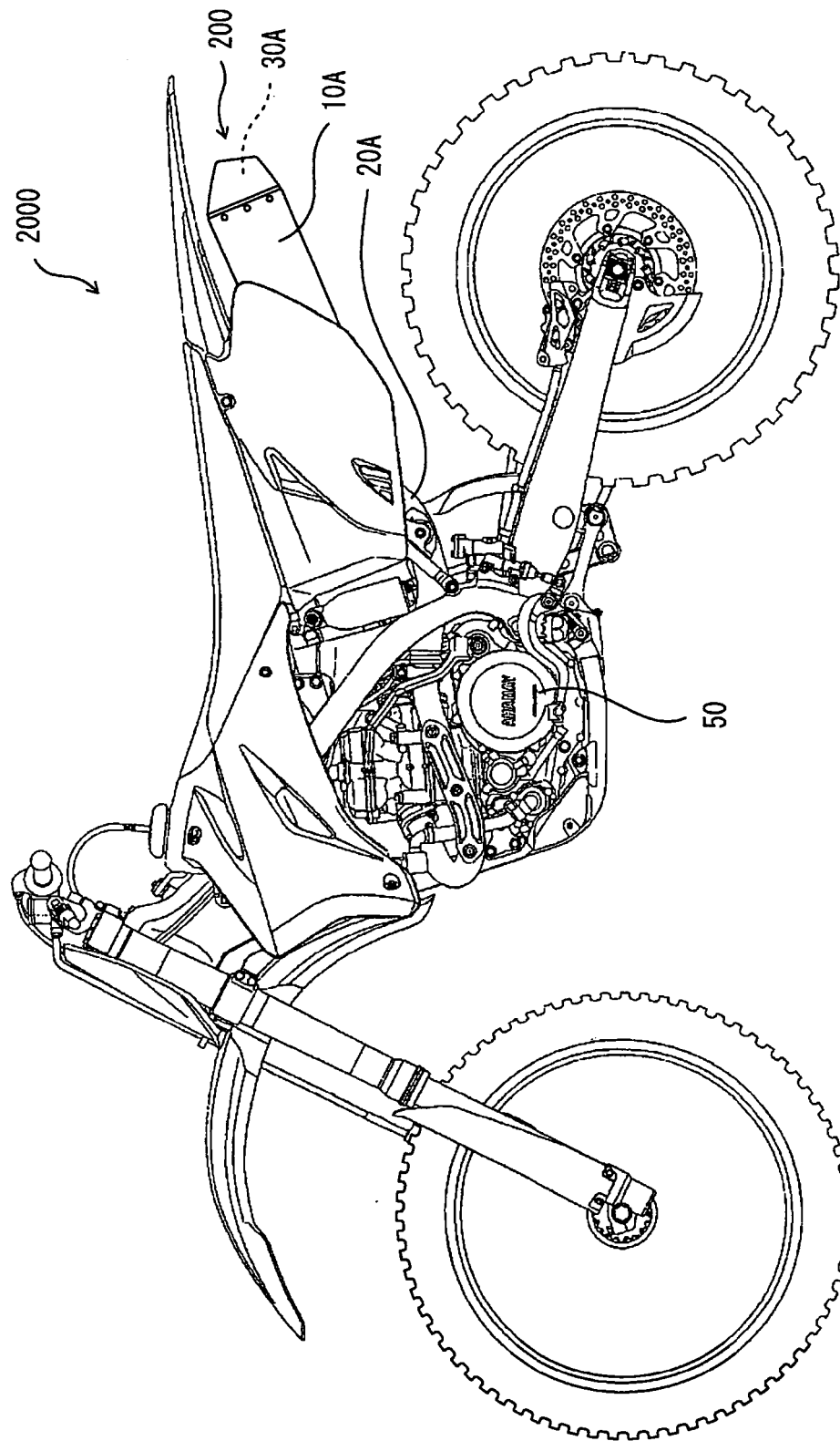
[Fig. 10]



[Fig. 11]



[Fig. 12]





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 25 1315

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 192 402 A (IWASHITA KANAU [JP] ET AL) 11 March 1980 (1980-03-11) * column 9, line 1 - line 11 * * column 9, line 28 - column 10, line 5 * * figures 3,6,17 * -----	1-24	INV. F01N1/00 F01N1/04 F01N1/10 F01N7/08 F01N7/18
X	JP 63 001714 A (YAMAHA MOTOR CO LTD) 6 January 1988 (1988-01-06) * abstract * -----	1-7, 10-13, 17,21,22	
X	FR 1 347 893 A (M. SIGISMOND WILMAN) 4 January 1964 (1964-01-04) * the whole document * -----	1-11,13, 14,21 17-20	
Y	GB 2 158 878 A (DIXON RACING LIMITED) 20 November 1985 (1985-11-20) * page 1, line 82 - line 120; figure 2 * -----	17-20	
X	DE 40 06 438 A1 (SUZUKI MOTOR CO [JP]) 6 September 1990 (1990-09-06) * column 2, line 62 - column 3, line 13; figures 1-3 * -----	1-3	
A		4-6	TECHNICAL FIELDS SEARCHED (IPC) F01N
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 22 June 2007	Examiner Zebst, Marc
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

6
EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 07 25 1315

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

22-06-2007

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4192402	A	11-03-1980	DE 2822971 A1	30-11-1978
			FR 2392228 A1	22-12-1978
JP 63001714	A	06-01-1988	JP 1952175 C	28-07-1995
			JP 6081901 B	19-10-1994
FR 1347893	A	04-01-1964	NONE	
GB 2158878	A	20-11-1985	NONE	
DE 4006438	A1	06-09-1990	AU 622768 B2	16-04-1992
			AU 5057290 A	13-09-1990
			IT 1239747 B	15-11-1993
			JP 2230917 A	13-09-1990
			JP 2687549 B2	08-12-1997
			US 5010731 A	30-04-1991

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 8312324 A [0003]
- JP 2003184541 A [0003]