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Vizanko(10) **Pub. No.: US 2006/0032700 A1**(43) **Pub. Date: Feb. 16, 2006**(54) **NOISE REDUCTION TECHNIQUE FOR
SNOWMOBILES****Publication Classification**(76) **Inventor: James Christopher Vizanko, Warroad,
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ABSTRACT

An air intake that reduces the transmission of noise from an internal combustion engine while maintaining high air intake flow rates. The air intake has a duct for delivering air to an internal combustion engine, and resonator volumes in communication with the inside of the duct, to selectively attenuate engine noise at certain frequencies and across certain frequency ranges.

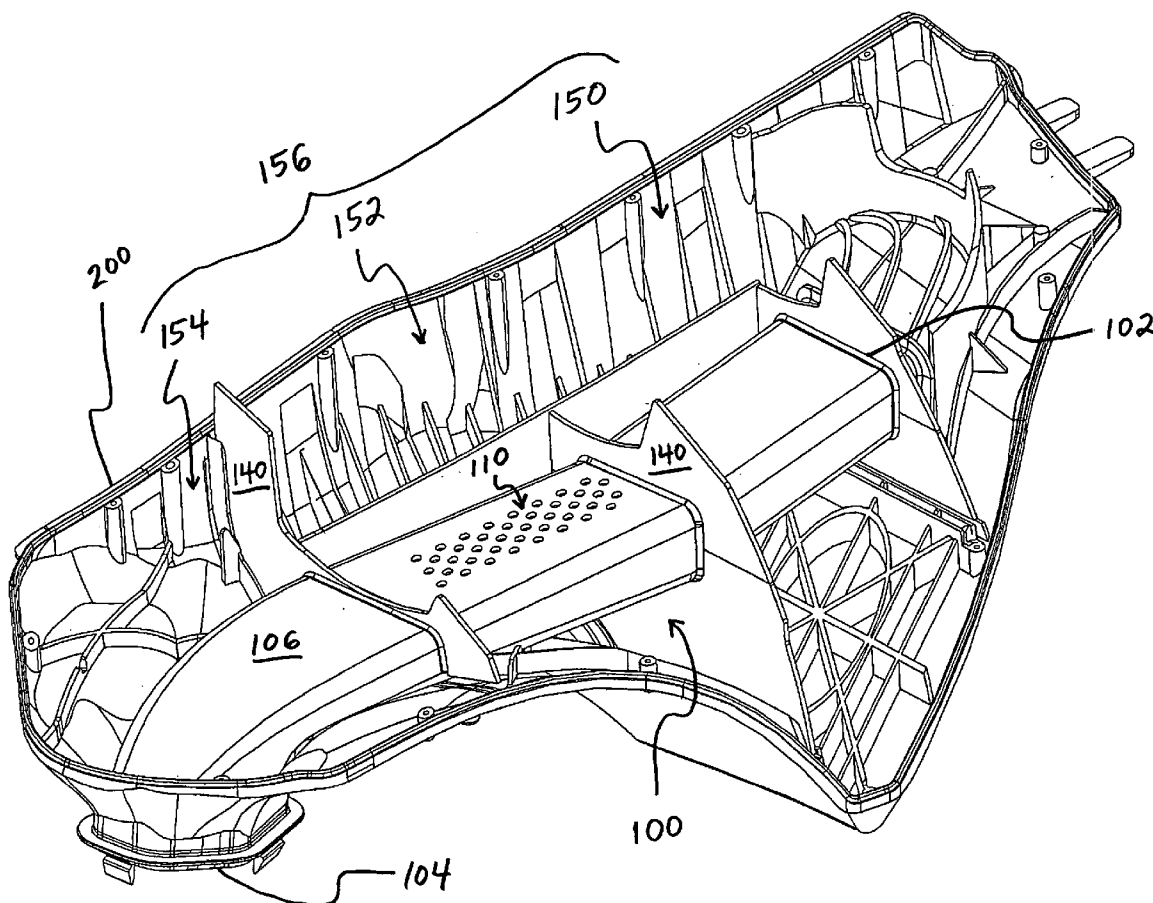
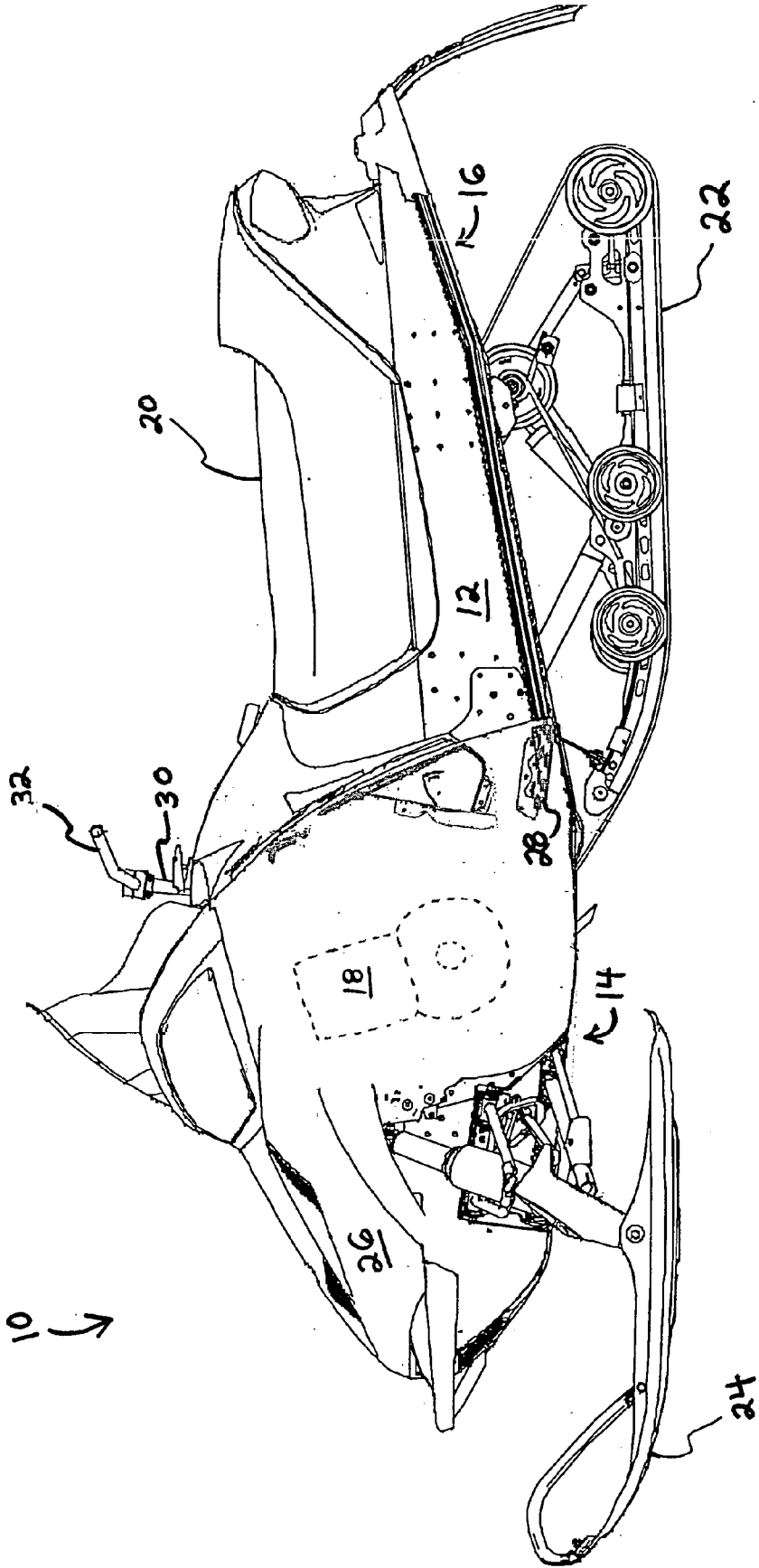
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FIG. 1



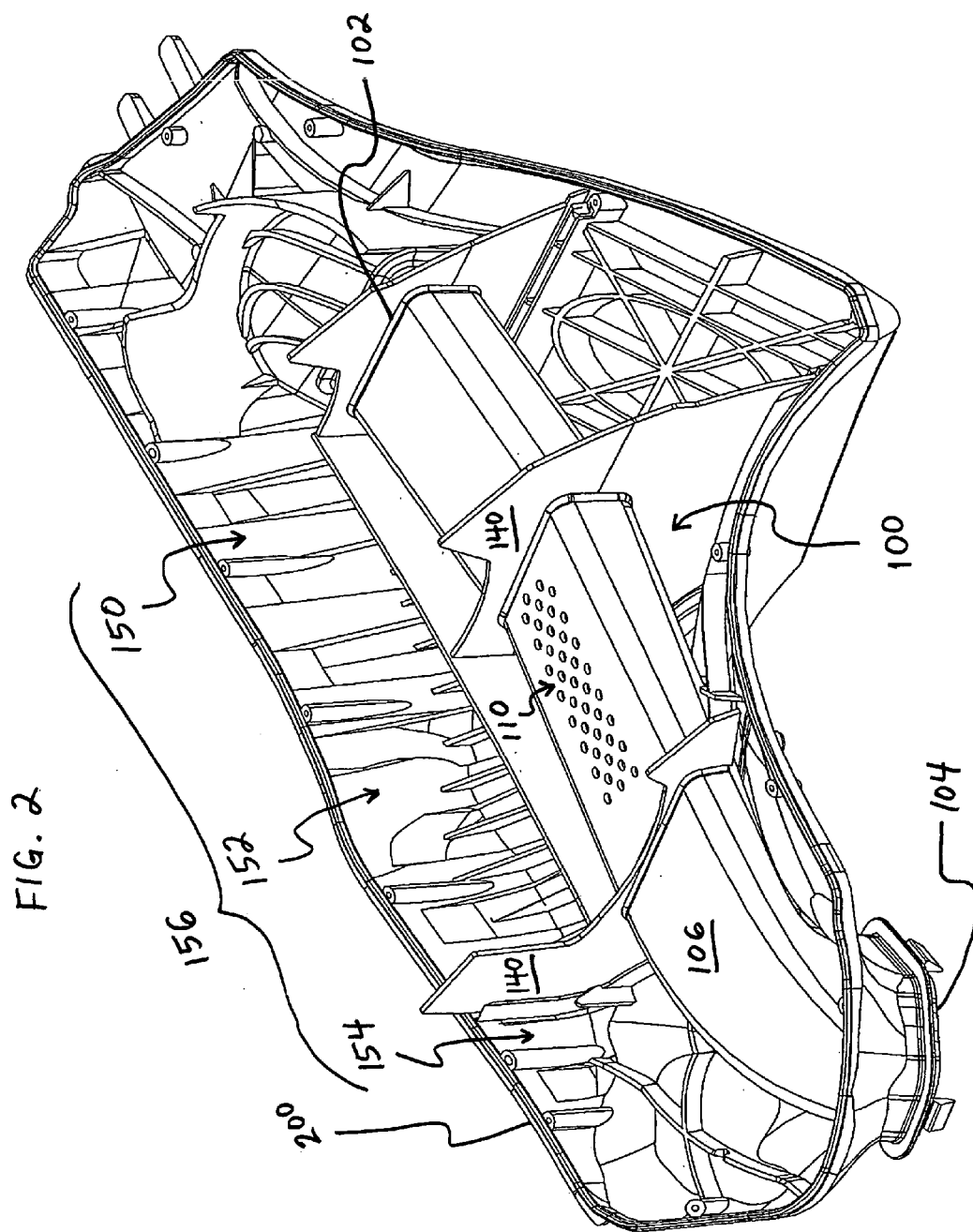


FIG. 3

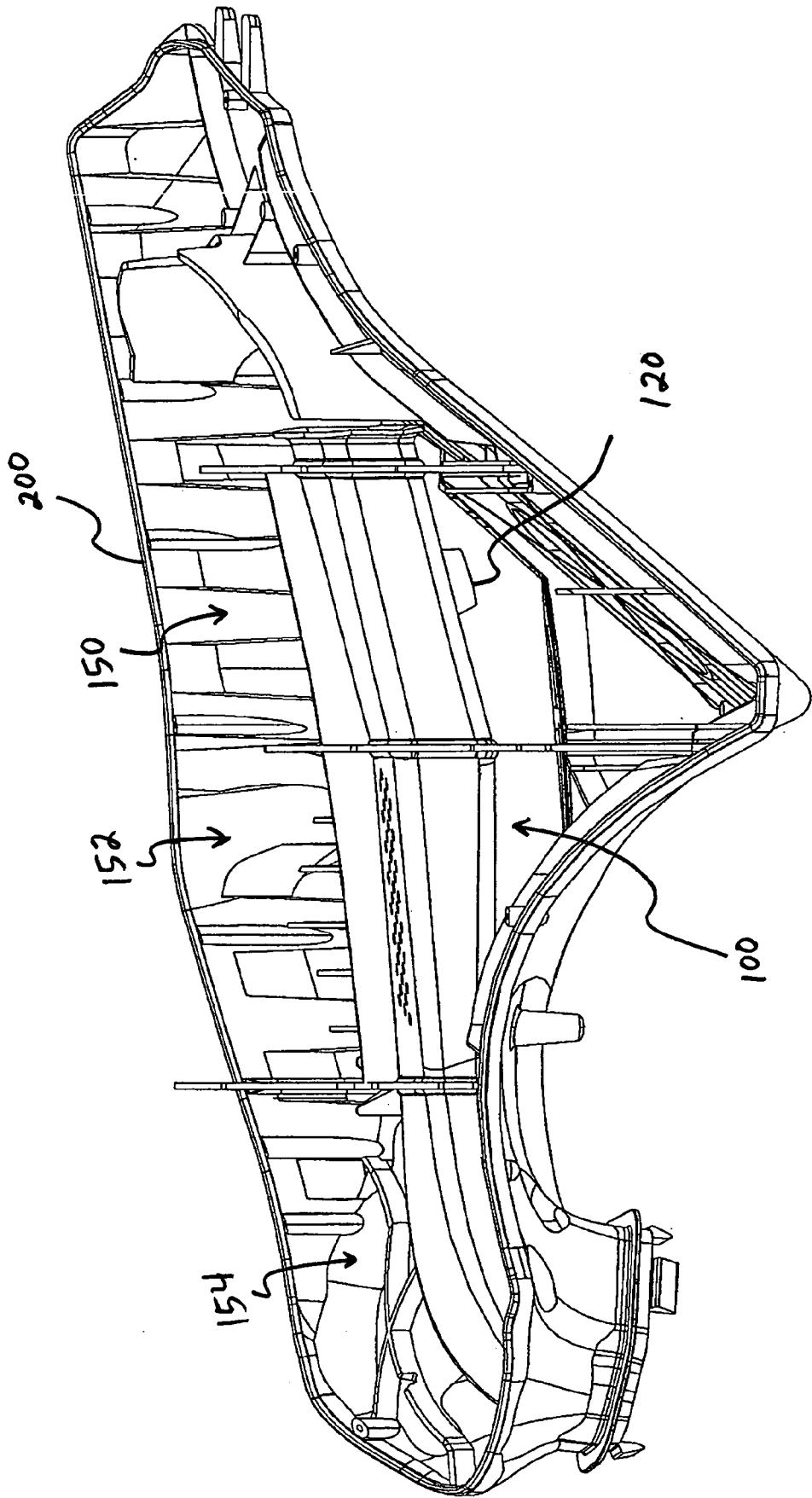
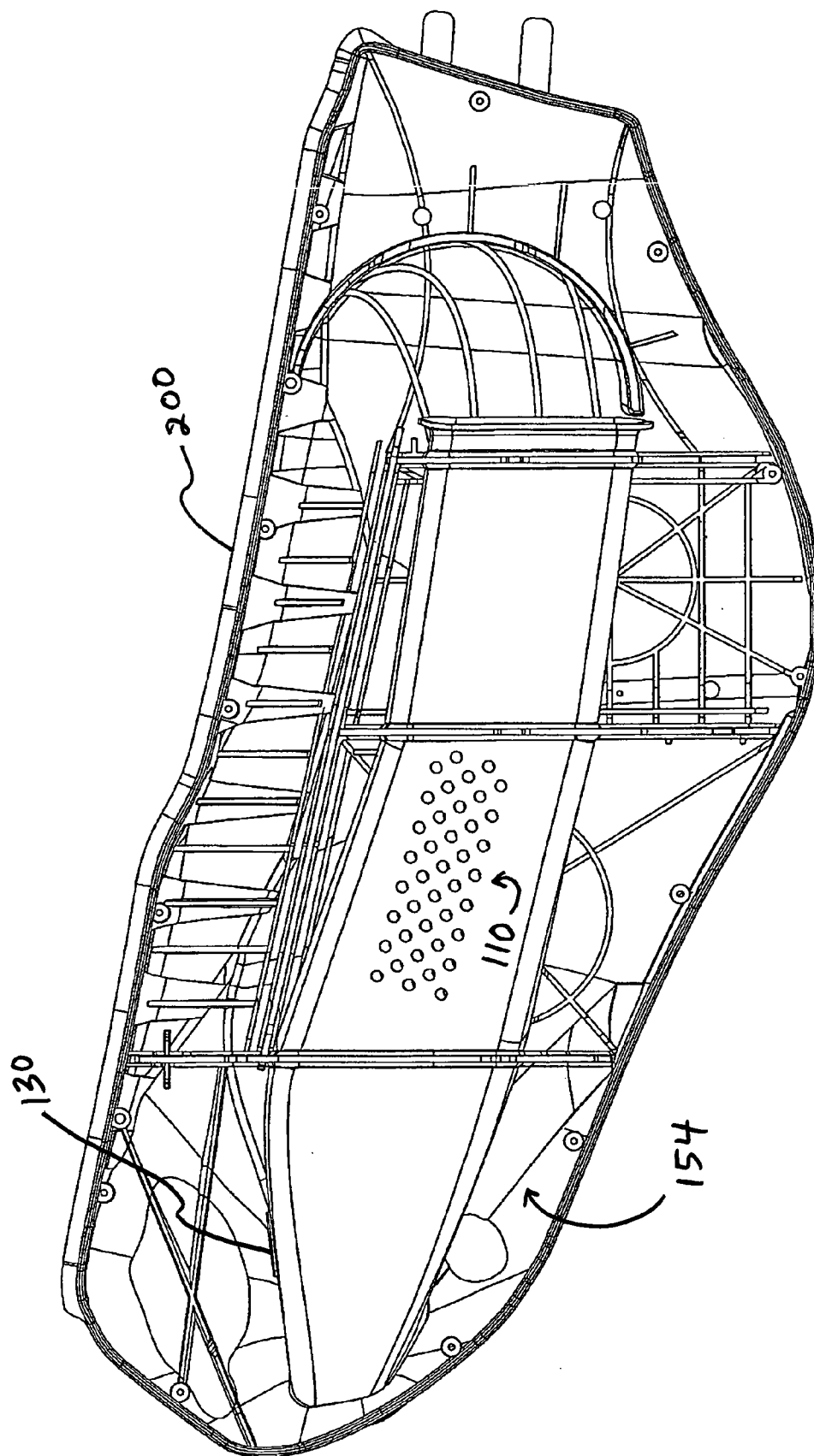


FIG. 4



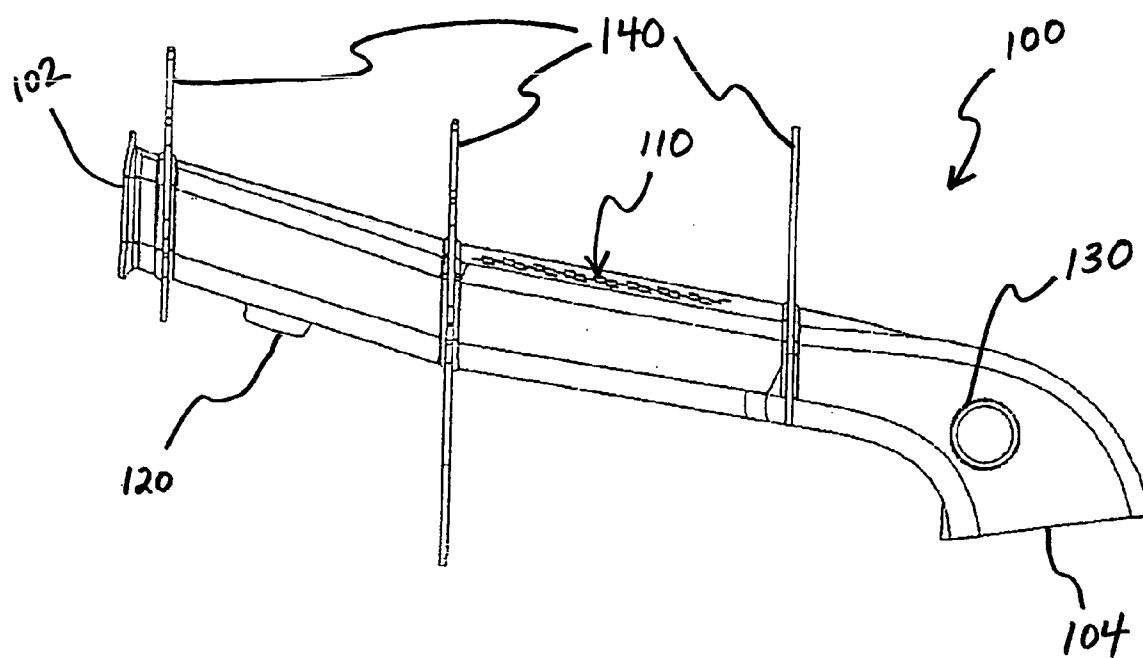


FIG. 5

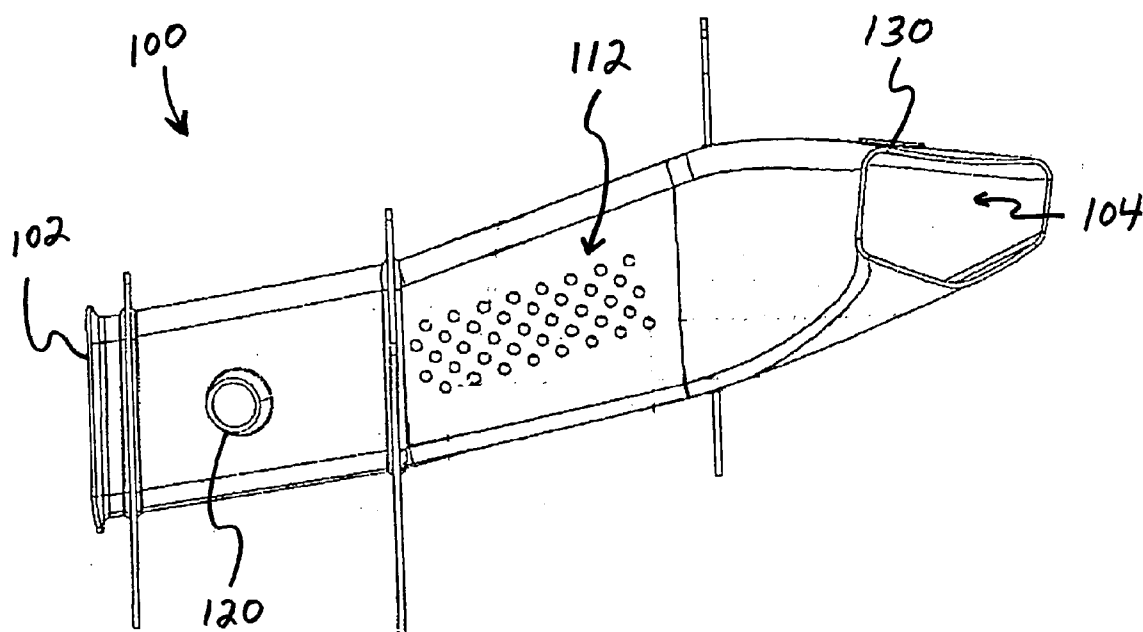
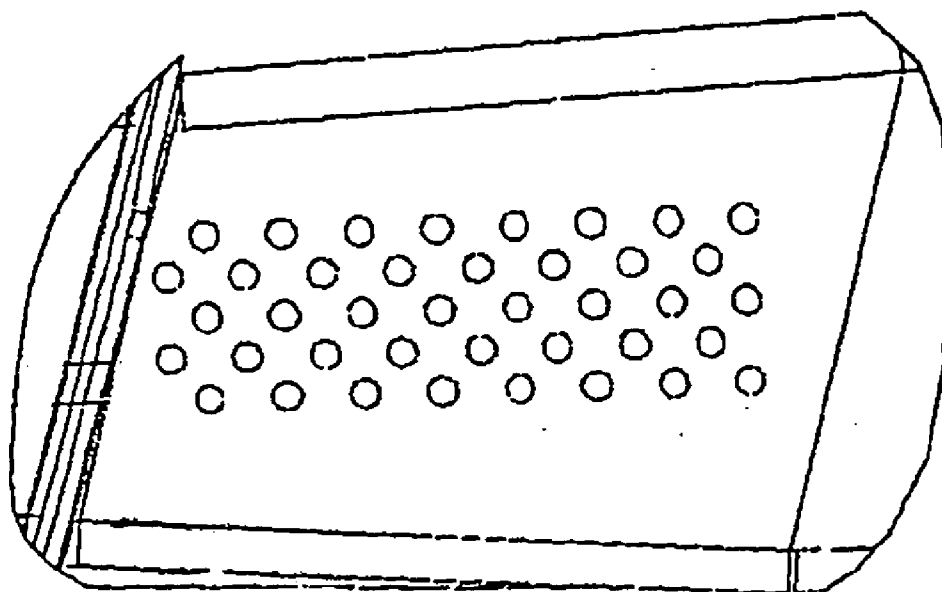


FIG. 6

FIG. 7



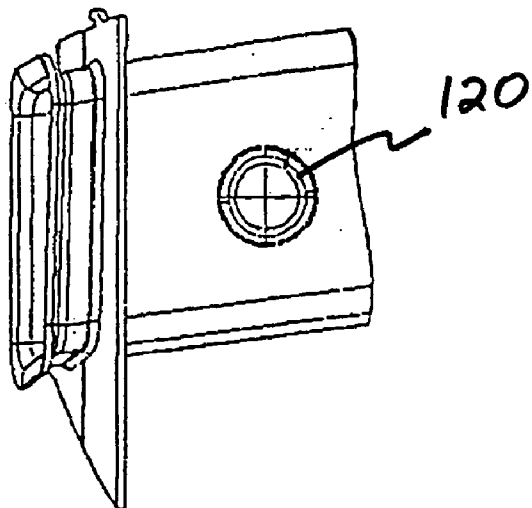


FIG. 8A

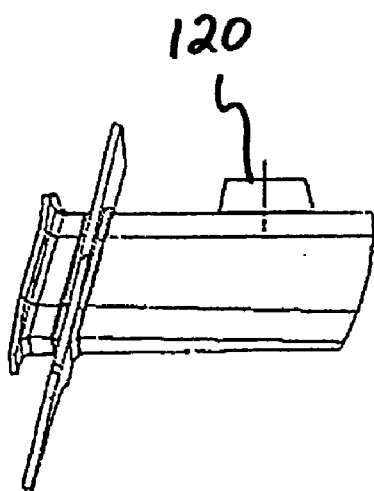


FIG. 8B

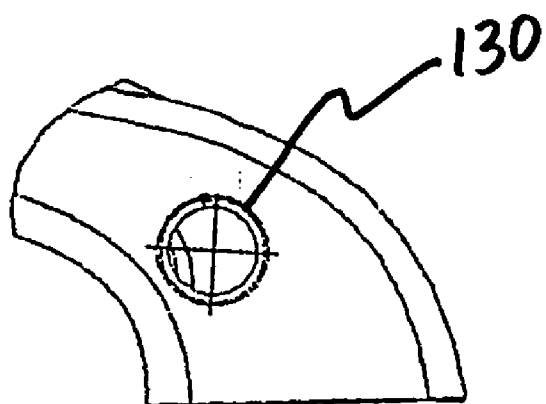


FIG. 9A

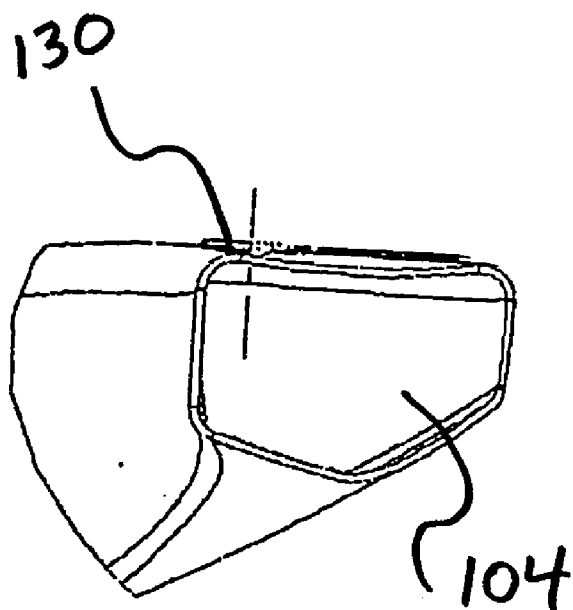


FIG. 9B

FIG. 10

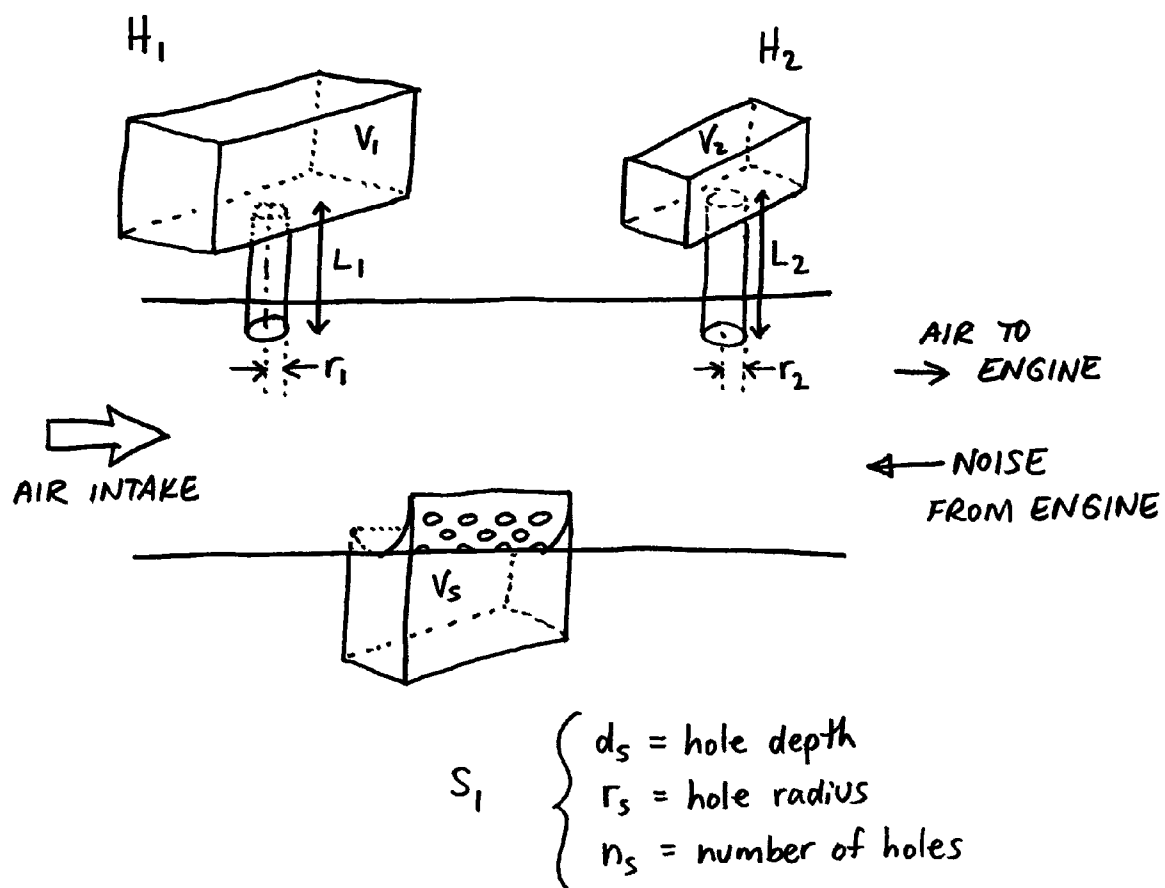


FIG. 11

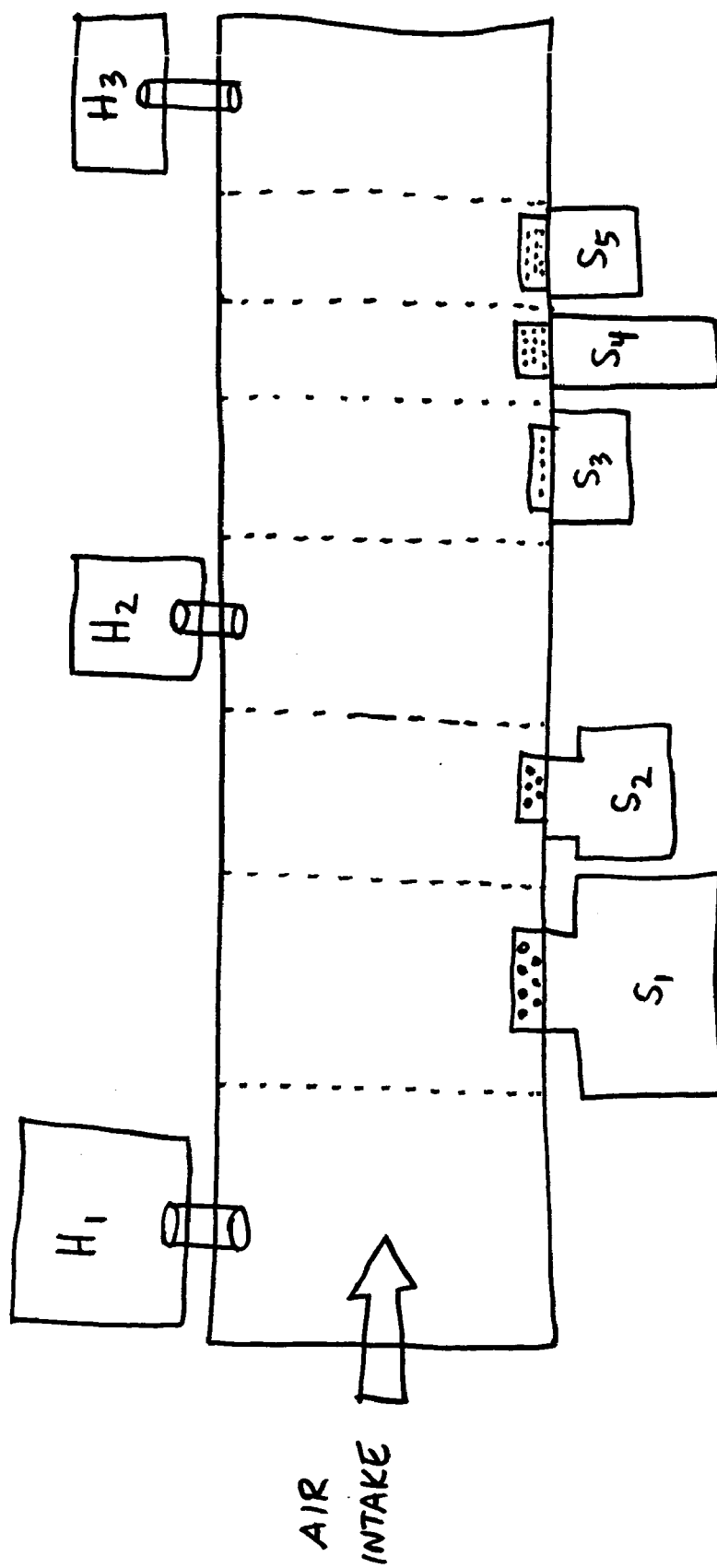


FIG. 12

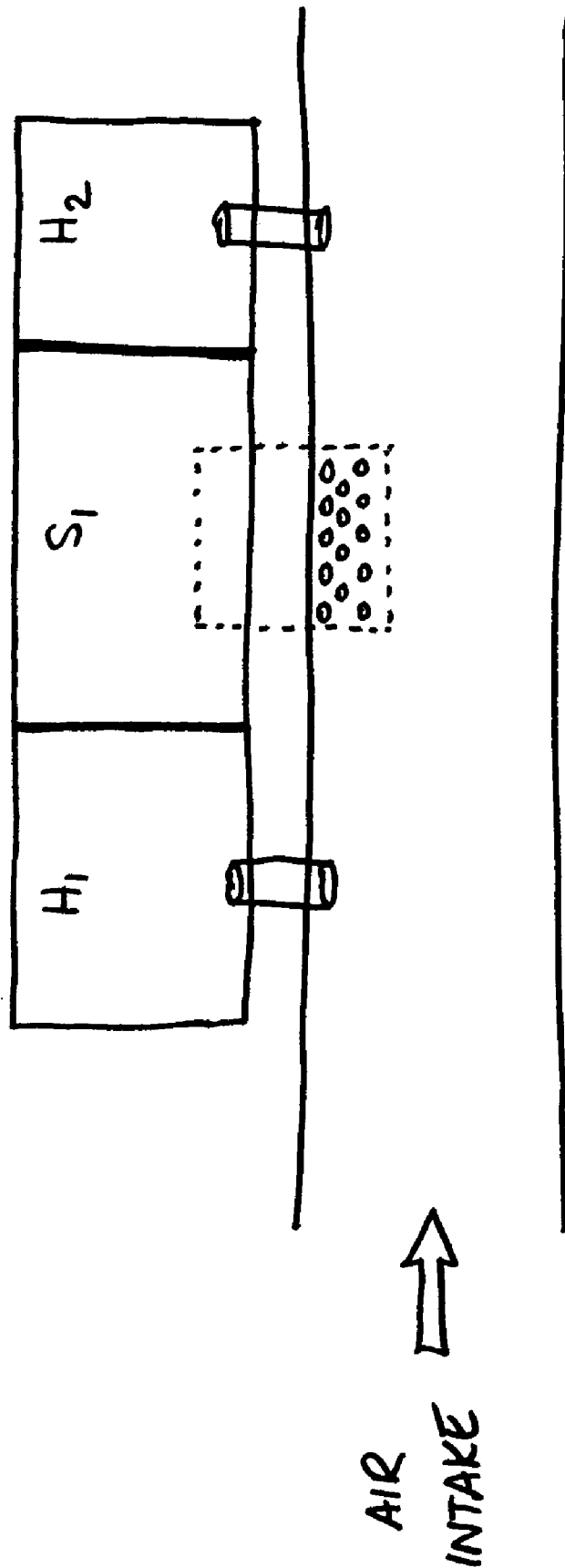


FIG. 13

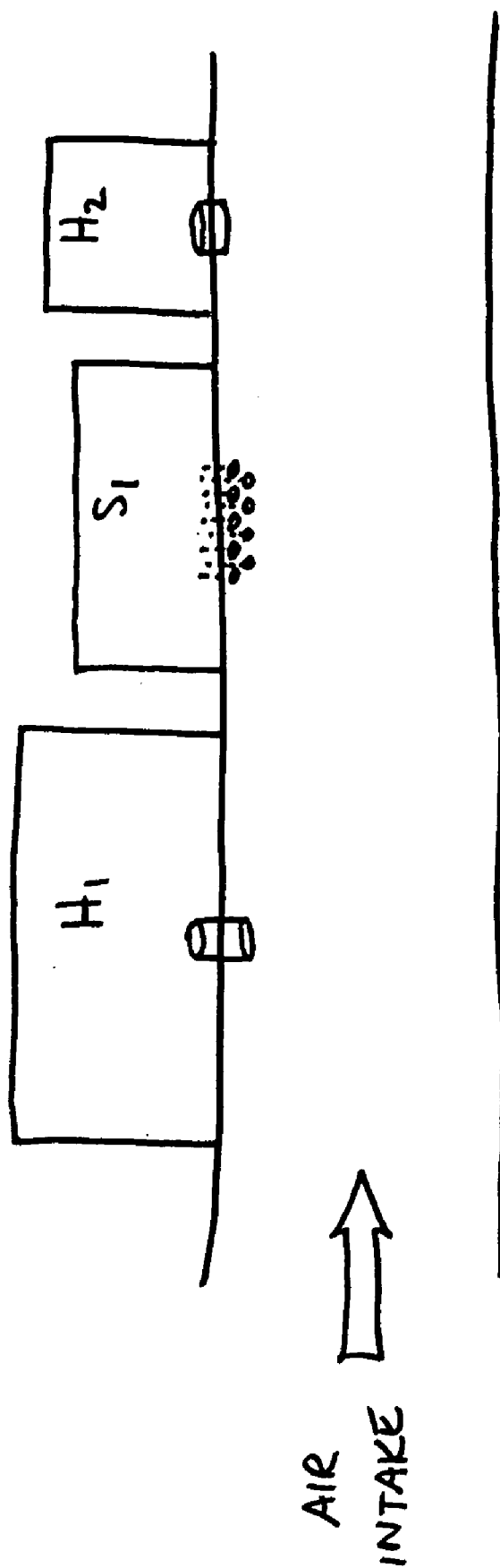


FIG. 14A

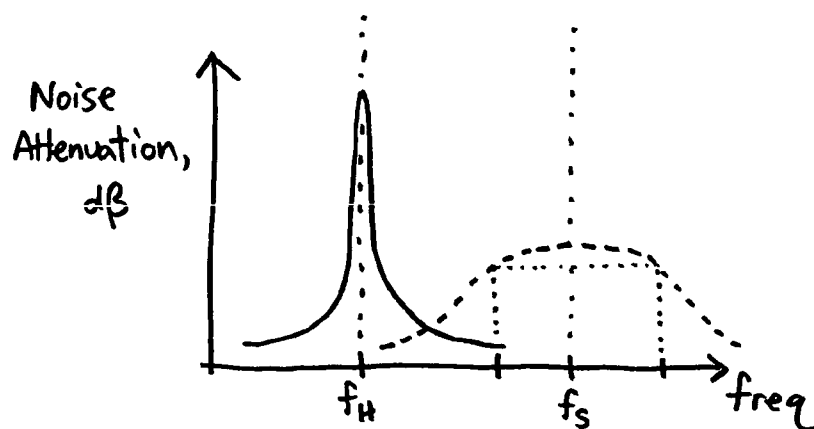


FIG. 14B

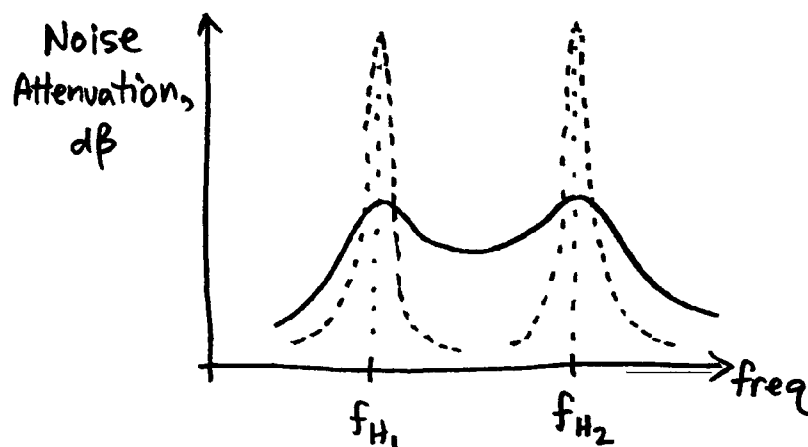
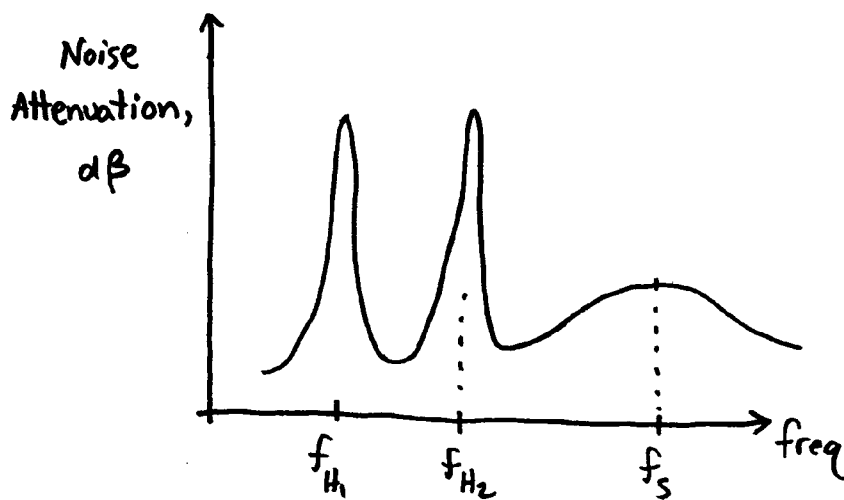


FIG. 14C



NOISE REDUCTION TECHNIQUE FOR SNOWMOBILES

FIELD OF THE INVENTION

[0001] The invention relates to air intake systems for recreational vehicles such as snowmobiles, all terrain vehicles (ATVs), and other similar vehicles. More particularly, the invention relates to air intake systems that reduce the transmission of noise from the engines of such vehicles.

BACKGROUND

[0002] Snowmobiles are popular land vehicles used as transportation vehicles or as recreational vehicles in cold and snowy conditions. Snowmobiles typically employ an internal combustion engine to drive an endless track to provide propulsion. Noise generated by snowmobile engines can be emitted from either the exhaust or the air intake of the engine, detracting from the enjoyment of the user, as well as potentially creating an environmental nuisance. Methods of addressing exhaust noise are known in the art. Methods of reducing air intake noise exist, but such methods tend to reduce air flow to the engine, thereby reducing engine efficiency and hence performance. Further, such methods do not adequately address the need to suppress noise energy at particular frequencies associated with snowmobile engines. Therefore, a need exists to reduce the amount of engine noise that is emitted from the air intake of snowmobile engines, particularly at certain frequencies, while maintaining a high amount of air flow to the engine to maximize engine performance.

BRIEF SUMMARY OF THE INVENTION

[0003] Some embodiments of the invention provide an air intake for a snowmobile that incorporates frequency selective noise attenuation while maintaining high air flow to the snowmobile engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] FIG. 1 is a side view of a snowmobile.

[0005] FIG. 2 is a front, top, left perspective view of an air intake duct within a housing.

[0006] FIG. 3 is a left side view of an air intake duct within a housing.

[0007] FIG. 4 is a top view of an air intake duct within a housing.

[0008] FIG. 5 is a right side view of an air intake duct and baffle plates according to an embodiment of the invention.

[0009] FIG. 6 is a bottom view of an air intake duct and baffle plates according to an embodiment of the invention.

[0010] FIG. 7 is a detailed view of the perforated area of a perforated (sleeve) resonator according to an embodiment of the invention.

[0011] FIG. 8 is a detailed view of the opening associated with a Helmholtz resonator according to an embodiment of the invention.

[0012] FIG. 9 is a detailed view of the opening associated with a Helmholtz resonator according to an embodiment of the invention.

[0013] FIG. 10 is a schematic view of an air intake duct with two Helmholtz resonators and one perforated sleeve resonator.

[0014] FIG. 11 is a schematic view of an air intake duct with a plurality of Helmholtz resonators, with at least one perforated sleeve resonator between each pair of adjacent Helmholtz resonators.

[0015] FIG. 12 is a schematic view of an air intake duct with a plurality of resonator volumes in accordance with an embodiment of the invention.

[0016] FIG. 13 is a schematic view of an air intake duct with a plurality of resonator volumes in accordance with an embodiment of the invention.

[0017] FIG. 14A is a chart showing the noise attenuation frequency response curves of typical Helmholtz resonators and perforated sleeve resonators.

[0018] FIG. 14B is a chart showing the noise attenuation frequency response curves of two Helmholtz resonators in close proximity to each other.

[0019] FIG. 14C is a chart showing the noise attenuation frequency response curves of two Helmholtz resonators separated by a perforated sleeve resonator.

DETAILED DESCRIPTION

[0020] The following detailed description should be read with reference to the drawings, in which like elements in different drawings are numbered identically. The drawings depict selected embodiments and are not intended to limit the scope of the invention. It will be understood that embodiments shown in the drawings and described above are merely for illustrative purposes, and are not intended to limit the scope of the invention as defined in the claims that follow.

[0021] A snowmobile 10 in accordance with some embodiments of the invention is shown in FIG. 1. Generally, snowmobile 10 includes a longitudinally extending chassis 12 having a front portion 14 and a rear portion 16. The chassis 12 supports and mounts several vehicle components, including an engine 18, a seat 20, a drive track 22, a pair of steerable skis 24, and a body assembly 26. In some embodiments, the chassis 12 supports the engine 18 proximate the front portion 14 and the seat 20 proximate the rear portion 16. The seat 20 is adapted to accommodate a rider in straddle fashion, and the engine 18 powers the drive track 22 operatively connected to the chassis 12 proximate the rear portion 16. Engine 18 can be an internal combustion engine, for example a two-stroke or four-stroke engine, that uses air and fuel to provide the combustion products. Means for supporting a rider's feet extending longitudinally below opposite lateral sides of the seat 20 may be provided. In some embodiments, the means may include footrests 28 that extend longitudinally below opposite lateral sides of the seat 20.

[0022] The chassis front portion 14 may be suitable for mounting the pair of steerable skis 24 and supporting the body assembly 26. The body assembly 26 may contain the engine 18. A steering post 30 is operatively connected to the pair of skis 24. Means for rotating the steering post 30 to effect steering may be provided, and the means for rotating may be supported by the steering post 30. In some embodi-

ments, the means for rotating may include a steering control, such as handlebars 32, supported by the steering post 30.

[0023] FIG. 2 shows a perspective view of an air intake duct 100 mounted within an air intake housing 200 for the delivery of air to an internal combustion engine for a snowmobile 10. Air intake duct 100 includes air inlet 102 for receiving incoming air into air intake duct 100, air outlet 104 for the delivery of air to an internal combustion engine, and wall 106, which forms a continuous flow path from air inlet 102 to air outlet 104. The shape of air intake duct 100 can be any suitable shape, such as rectangular, cylindrical, or elliptical, to account for manufacturing and/or packaging considerations. Air intake housing 200 is shown cut-away to show internal details. A space 156 is defined by the enclosed volume between the outer surface of wall 106 and the inner surface of air intake housing 200. Baffle plates 140 extend outwardly from air intake duct 100, and are oriented generally perpendicular to the direction of air flow through air intake duct 100. Baffle plates 140 thereby divide space 156 into three resonator volumes 150, 152, 154.

[0024] Two of the resonator volumes can form Helmholtz resonators for the air intake duct 100 by providing fluid communication through openings 120, 130 (see FIGS. 3-5) in the wall 106 of the air intake duct 100 between each of the two resonator volumes and the space within the air intake duct 100. The Helmholtz resonators function to attenuate noise energy from the engine at certain frequencies. The particular frequency attenuated by each such Helmholtz resonator is a function of several physical parameters including the radius of the opening, the length of the “neck” of the opening, the volume of the resonator volume, and the speed of sound. A typical Helmholtz resonator can function to sharply attenuate noise energy in a relatively narrow range of frequencies. However, if two Helmholtz resonators are placed in close proximity to each other, the “sharpness” of the frequency response of each will be lessened such that a broader range of frequencies will be attenuated, but to a lesser degree. (“Sharpness,” as used here, roughly corresponds to the “Q” of a resonant circuit, a ratio that is inversely proportional to the bandwidth of the frequency response.) Increasing the distance between two Helmholtz resonators tends to “insulate” them from this effect, i.e., the separation tends to cause the Helmholtz resonators to act somewhat independently of each other, thereby focusing the attenuation response around two frequencies of interest. The insulating effect may be provided or enhanced by including, for example, other physical structures in the space that separates the two Helmholtz resonators.

[0025] In some embodiments, such as the one shown in FIG. 2, resonator volume 152 is positioned between two Helmholtz resonator volumes 150, 154. Fluid communication may be provided between resonator volume 152 and the inside of air intake duct 100 through a perforated area 110 in the top portion of air intake duct 100. Perforated area 110 may thereby form a “perforated sleeve” type resonator which may insulate the two Helmholtz resonators from interacting with each other, as described above. Similarly, a perforated area 112 (see FIG. 6) may be located in the bottom portion of air intake duct 100. A perforated sleeve type resonator typically functions to attenuate noise energy to a lesser degree, and over a relatively broad range of frequencies, as compared with a Helmholtz resonator. Physical parameters such as the number, size, and shape of the

holes, the depth of the duct wall 106, and the volume of the associated resonator volume, affects the frequency and attenuation characteristics of the perforated sleeve type resonator.

[0026] FIG. 3 is a left, side view of the air intake duct 100 mounted within housing 200, providing a cross sectional view of the three resonator volumes 150, 152, 154. Helmholtz resonator opening 120 is shown protruding from the bottom portion of air intake duct 100, providing fluid communication between the first resonator volume 150 and the inside of air intake duct 100.

[0027] FIG. 4 is a top view of air intake duct 100 positioned within air intake housing 200. Helmholtz resonator opening 130 is seen protruding from the right side of air intake duct 100, providing fluid communication between third resonator volume 154 and the space within air intake duct 100.

[0028] FIG. 5 is a right side view of air intake duct 100, showing baffle plates 140 mounted thereto. As shown in FIG. 5, Helmholtz resonator openings 120, 130 are spaced longitudinally at or near the air inlet 102 and air outlet 104, respectively. The perforated area 110, as well as perforated area 112 (not shown), are located between Helmholtz resonator openings 120, 130 in the top and bottom portions of wall 106 of air intake duct 100. Baffle plates 140 are shown for separating the resonator volumes 150, 152, and 154, such that the noise attenuation effect of each of the three resonator volumes is made to function substantially independently of the effect created by the other two resonator volumes. The larger volume of resonator volume 150 (relative to resonator volume 154) would tend to make the Helmholtz resonator associated with volume 150 attenuate noise energy at lower frequencies than the Helmholtz resonator associated with opening 130, assuming other factors (such as the length of the neck portion of the openings 120, 130, and the diameter of openings 120, 130) are held constant.

[0029] FIG. 6 is a bottom view of air intake duct 100 showing a detailed description of perforated area 112. The particular pattern and arrangement of perforations shown is for illustrative purposes. As would be known by a person of ordinary skill in the art, the pattern and arrangement of perforations may be varied to achieve a somewhat different noise response without departing from the scope of the invention.

[0030] FIG. 7 is a close up view of perforated area 110 or 112, showing the relative spacing and positioning of the apertures that comprise perforated areas 110, 112.

[0031] FIGS. 8(a) and 8(b) are two views of Helmholtz resonator opening 120. Similarly, FIGS. 9(a) and 9(b) provide views of Helmholtz resonator opening 130. For illustrative purposes only, the relative lengths of the openings 120, 130 is shown. The longer “neck” portion of opening 120 (relative to opening 130) would tend to make the Helmholtz resonator associated with opening 120 attenuate noise energy at lower frequencies than the Helmholtz resonator associated with opening 130, assuming other factors (such as the volume of the respective resonator volumes 150, 154, and the diameter of openings 120, 130) are held constant.

[0032] FIG. 10 is a schematic diagram of an air intake duct 100 according to an embodiment of the invention. FIG.

10 shows two Helmholtz resonators and a perforated sleeve resonator in fluid communication with the space inside air intake duct **100**. The parameters that define the frequency response characteristics of each Helmholtz resonator are indicated in **FIG. 10**, namely, the Helmholtz resonator volumes V_1 , V_2 , the length of the neck portions L_1 , L_2 between the air intake duct **100** and the resonator volumes V_1 , V_2 , and the radius of the openings r_1 , r_2 . Similarly, the parameters that define the frequency characteristic of the perforated sleeve resonator are indicated as resonator volume V_s , hole depth d_s , hole radius r_s , and the number of holes n_s .

[0033] **FIG. 11** is a schematic diagram of an air intake duct **100** showing a plurality of Helmholtz resonators in accordance with an embodiment of the invention. As shown, at least one perforated sleeve resonator is positioned longitudinally between each pair of adjacent Helmholtz resonators. As would be obvious to one of ordinary skill in the art, the openings of the Helmholtz resonators could be oriented to project from different directions around the periphery of wall **106**, for example, to facilitate packaging and manufacturing constraints of the vehicle.

[0034] **FIG. 12** is a schematic diagram of an air intake duct in fluid communication with a plurality of longitudinally spaced resonator volumes that are separated from one another by a wall or baffle plate between each pair of adjacent resonator volumes. As shown, the resonator volumes share a common housing with each other, but are separated from the air intake duct and have openings providing the fluid communication path between the air intake duct and each respective resonator volume.

[0035] **FIG. 13** is a schematic diagram of an air intake duct **100** and a plurality of resonator volumes that are formed in part by the outer surface of the wall **106** of the air intake duct **100**. As shown, the resonator volumes cover a portion of the outer wall **106** of air intake duct **100**, but do not extend circumferentially around the entire air intake duct **100**. As would be obvious to one having ordinary skill in the art, the resonator volumes shown in **FIGS. 11-13** could be combined to form alternate embodiments of the invention without departing from the scope of the technique described herein. As would also be obvious to one having ordinary skill in the art, any of the resonator volumes shown in **FIGS. 11-13** could be extended circumferentially to surround the entire outer wall **106** of air intake duct **100**, or any portions thereof.

[0036] **FIG. 14A** is a frequency response curve, showing the noise attenuation characteristics of a typical Helmholtz resonator, as well as a typical perforated sleeve resonator. As shown, the Helmholtz resonator frequency response curve provides a relatively high degree of attenuation over a relatively narrow frequency range centered on the Helmholtz resonator frequency, F_H , which is determined in part by the volume, neck length, and hole radius of the particular Helmholtz resonator. The noise attenuation characteristic of the perforated sleeve resonator is also shown in **FIG. 14A**. As shown, the perforated sleeve resonator provides a relatively lesser degree of attenuation over a relatively broader range of frequencies than the Helmholtz resonator. This is indicated in **FIG. 14A** by the dashed frequency response curve of the perforated sleeve resonator, having a lower peak attenuation at frequency F_s , and exhibiting a generally

bell-shaped response. The frequency response curve of the perforated sleeve resonator shown in **FIG. 14A** is provided for illustration, not limitation, and may be influenced by factors such as the air intake flow rate, among other factors.

[0037] **FIG. 14B** is illustrative of a problem experienced when using more than one Helmholtz resonator in a given structure. As shown in **FIG. 14B**, the placement of two Helmholtz resonators in close proximity to each other in a particular structure will cause a lesser degree of attenuation and a broader range of frequencies attenuated.

[0038] **FIG. 14C** shows a frequency response curve achieved by separating two adjacent Helmholtz resonators in a structure by placing at least one sleeve resonator between the two Helmholtz resonators, which isolates the Helmholtz resonators from each other to a certain degree by adding to the distance between the two Helmholtz resonators and causing them to act somewhat independently of each other.

[0039] Thus, embodiments of the Noise Reduction Technique For Snowmobiles are disclosed. One skilled in the art will appreciate that the technique can be practiced with embodiments other than those disclosed. The disclosed embodiments are presented for purposes of illustration and not limitation, and the invention is limited only by the claims that follow.

What is claimed is:

1. An air intake for an internal combustion engine, comprising:

a duct for directing air intake flow through an interior space in the duct towards an engine for use in internal combustion, the duct having an inlet and an outlet;

a housing surrounding the duct and defining an enclosed space between the duct and the housing; and

baffle plates extending outwardly from the duct to the housing and dividing the enclosed space into a plurality of resonator volumes, the duct having openings in walls of the duct, the openings establishing fluid communication paths between the interior space of the duct and the resonator volumes to form at least two Helmholtz resonators to attenuate sound pressure energy emanating from the internal combustion engine, the at least two Helmholtz resonators being insulated from each other.

2. The air intake of claim 1, wherein the at least two Helmholtz resonators are separated by at least one of the resonator volumes to insulate the at least two Helmholtz resonators from each other.

3. The air intake of claim 1, wherein a portion of the duct is perforated, the perforations establishing fluid communication paths between the interior space of the duct and at least one of the resonator volumes to form at least one sleeve resonator to attenuate sound pressure energy emanating from the internal combustion engine.

4. The air intake of claim 3, wherein the at least one sleeve resonator is positioned between the at least two Helmholtz resonators to insulate the at least two Helmholtz resonators from each other.

5. The air intake of claim 1, wherein the at least two Helmholtz resonators attenuate sound of different wavelengths.

6. The air intake of claim 1, wherein the at least two Helmholtz resonators attenuate sound under 1000 Hz.

7. The air intake of claim 1, wherein at least one of the openings for the at least two Helmholtz resonators faces in a different direction.

8. An air intake for an internal combustion engine, comprising:

a duct for directing air intake flow through an interior space in the duct towards an engine for use in internal combustion, the duct having an inlet and an outlet;

the duct having openings in walls of the duct, the openings establishing fluid communication paths between the interior space of the duct and enclosed resonator volumes to form two separate Helmholtz resonators to attenuate sound pressure energy emanating from the internal combustion engine, the two Helmholtz resonators being insulated from each other.

9. The air intake of claim 8, wherein the two Helmholtz resonators are separated by another resonator volume to insulate the two Helmholtz resonators from each other.

10. The air intake of claim 8, wherein a portion of the duct is perforated, the perforations establishing fluid communication paths between the interior space of the duct and at least one of the resonator volumes to form at least one sleeve resonator that attenuates sound pressure energy emanating from the internal combustion engine.

11. The air intake of claim 10, wherein the at least one sleeve resonator is positioned between the two Helmholtz resonators to insulate the two Helmholtz resonators from each other.

12. The air intake of claim 8, wherein the two Helmholtz resonators are spaced apart a sufficient distance to insulate the two Helmholtz resonators from each other.

13. The air intake of claim 8, further including a housing at least partially surrounding the duct and forming the enclosed resonator volumes between the duct and the housing.

14. The air intake of claim 8, wherein the enclosed resonator volumes forming the two Helmholtz resonators are formed in part by the outside surface of the duct.

15. The air intake of claim 1, wherein each of the at least two Helmholtz resonators is adapted to attenuate sound pressure energy at or around a particular frequency.

16. The air intake of claim 15, wherein two or more baffle plates extend between the wall of the duct and the housing, dividing the enclosed space between the wall of the duct and the housing into three resonator volumes, and wherein the air intake includes two Helmholtz resonators.

17. The air intake of claim 16, wherein the two Helmholtz resonators include a first resonator volume located nearest the air intake inlet and a third resonator volume located nearest the air intake outlet.

18. The air intake of claim 17, further comprising at least one perforated area in the wall of the duct, wherein the at least one perforated area places the duct in fluid communication with a second resonator volume positioned between the first and third resonator volumes, forming a perforated sleeve resonator adapted to attenuate sound pressure energy emanating from the internal combustion engine over a range of frequencies.

19. The air intake of claim 17, wherein the two Helmholtz resonators are adapted to attenuate sound pressure energy emanating from the internal combustion engine at frequencies at or around 125 hertz and 250 hertz.

20. The air intake of claim 18, wherein the perforated sleeve resonator comprises two or more perforated areas.

21. The air intake of claim 18, wherein the duct and the housing form a continuous air intake flow path for maximizing air flow and improving engine efficiency.

22. The air intake of claim 18, wherein the two Helmholtz resonators are adapted to attenuate sound pressure energy emanating from the internal combustion engine at frequencies at or around 125 hertz and 250 hertz.

23. The air intake of claim 22, wherein the Helmholtz resonator adapted to attenuate sound pressure energy at frequencies at or around 125 hertz includes the first resonator volume and the Helmholtz resonator adapted to attenuate sound pressure energy at frequencies at or around 250 hertz includes the third resonator volume.

24. The air intake of claim 23, wherein the perforated sleeve resonator is adapted to attenuate sound pressure energy emanating from the internal combustion engine over a frequency range from about 275 hertz to about 1000 hertz.

25. The air intake of claim 23, wherein the perforated sleeve resonator is adapted to attenuate sound pressure energy emanating from the internal combustion engine over a frequency range from about 300 hertz to about 600 hertz.

26. A snowmobile having skis, an endless track propulsion mechanism, a steering column for turning the skis, an internal combustion engine for driving the endless track, and an air intake system for delivering air to the internal combustion engine, the air intake system comprising:

a duct for directing air intake flow through an interior space in the duct towards an engine for use in internal combustion, the duct having an inlet and an outlet;

a housing surrounding the duct and defining an enclosed space between the duct and the housing; and

baffle plates extending outwardly from the duct to the housing and dividing the enclosed space into a plurality of resonator volumes, the duct having openings in walls of the duct, the openings establishing fluid communication paths between the interior space of the duct and at least two of the resonator volumes to form at least two Helmholtz resonators to attenuate sound pressure energy emanating from the internal combustion engine, the duct further having a perforated portion establishing fluid communication between the interior space of the duct and at least one of the resonator volumes to form at least one sleeve resonator that attenuates sound pressure energy emanating from the internal combustion engine, wherein the at least two Helmholtz resonators are insulated from each other by the at least one sleeve resonator.

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