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(54) Title of the Invention: **A vehicle bonnet, a method of assembling a vehicle bonnet and a vehicle comprising a bonnet**
Abstract Title: **A vehicle bonnet comprising a resonator**

(57) Aspects of the present invention relate to a vehicle bonnet, a method of assembling a vehicle bonnet and a vehicle including a vehicle bonnet. The vehicle bonnet 100 or hood comprises a first panel 110, a second panel 120, and a cavity 130 between the first panel and the second panel, wherein the cavity is configured to receive intake air; and a resonator 140, wherein the resonator is arranged to attenuate acoustic waves within the cavity. The resonator may be a quarter wavelength resonator and the bonnet may also comprise an insert 300 to disrupt air pressure pulsations entering the cavity from the air intake duct. The invention reduces vibration of the bonnet surface and noise which may be undesirable to a user.

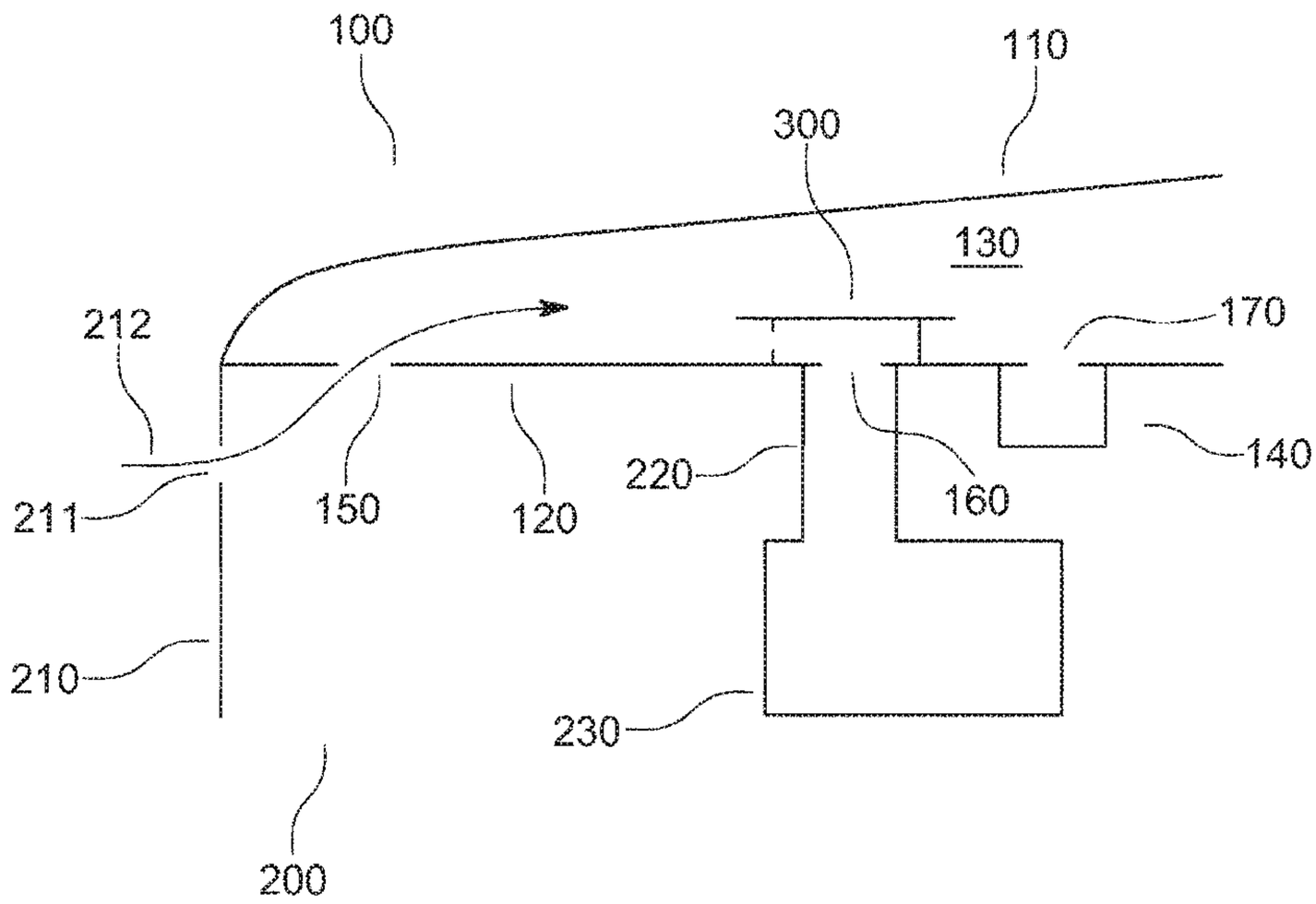

FIG. 3

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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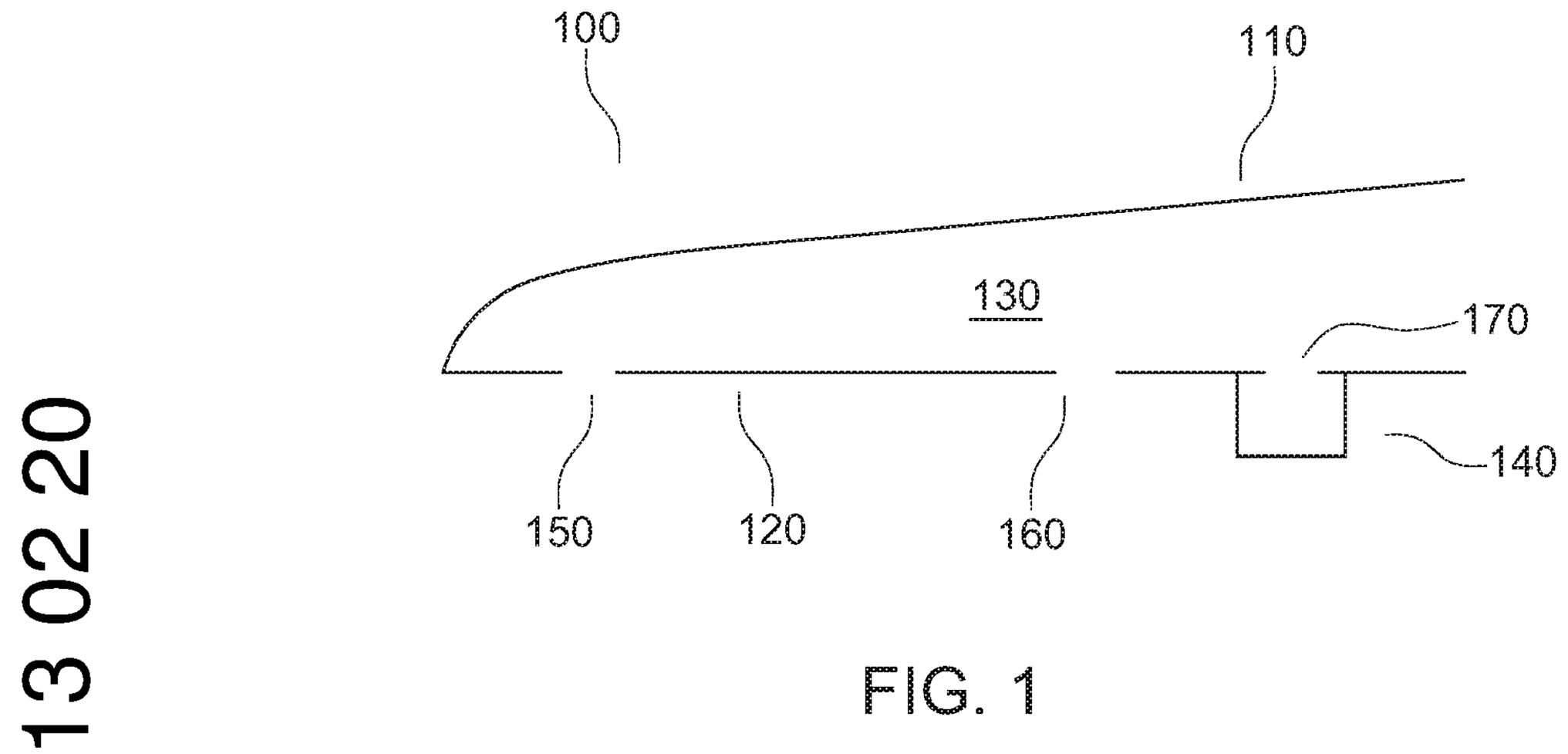

FIG. 1

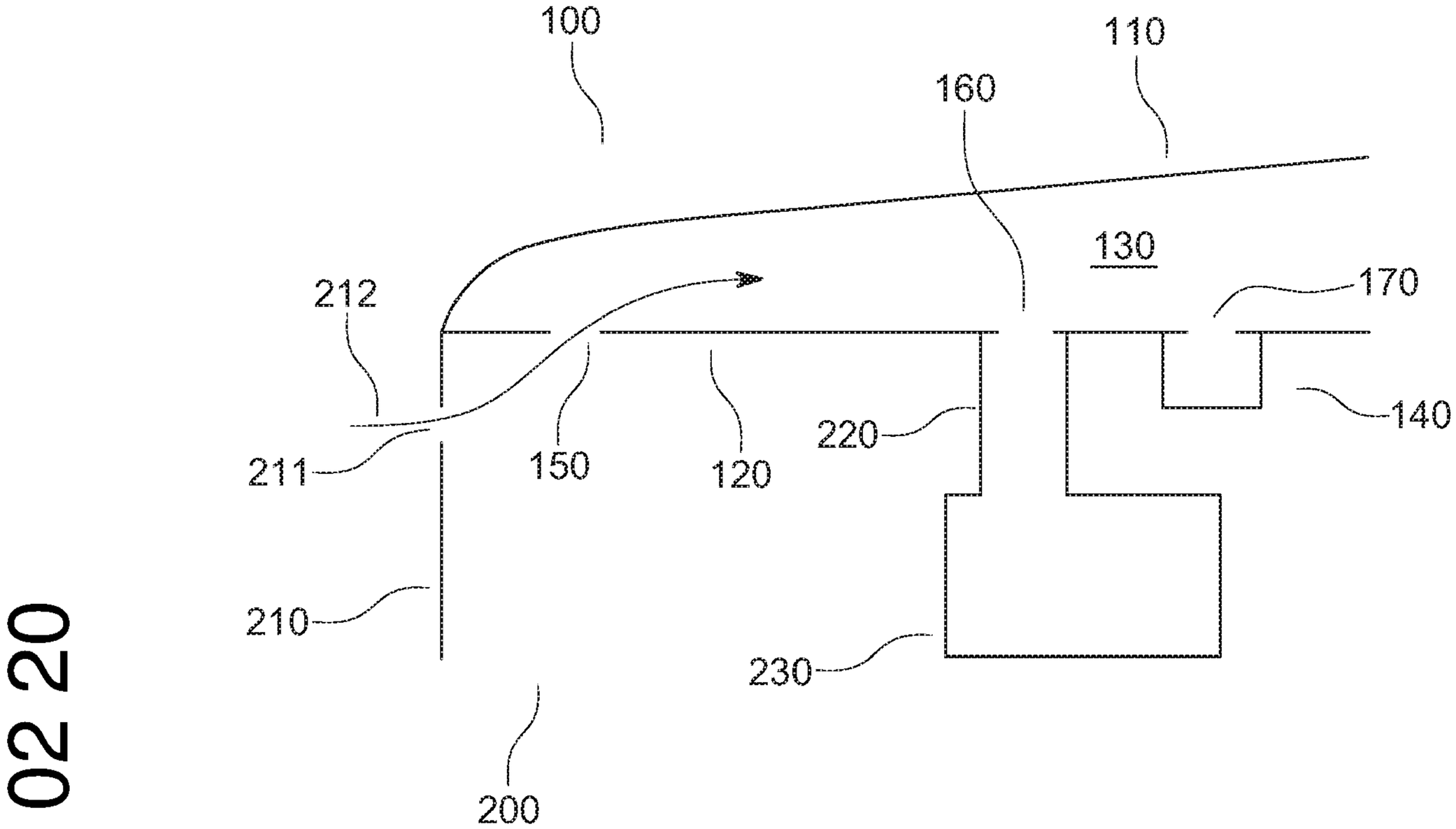

FIG. 2

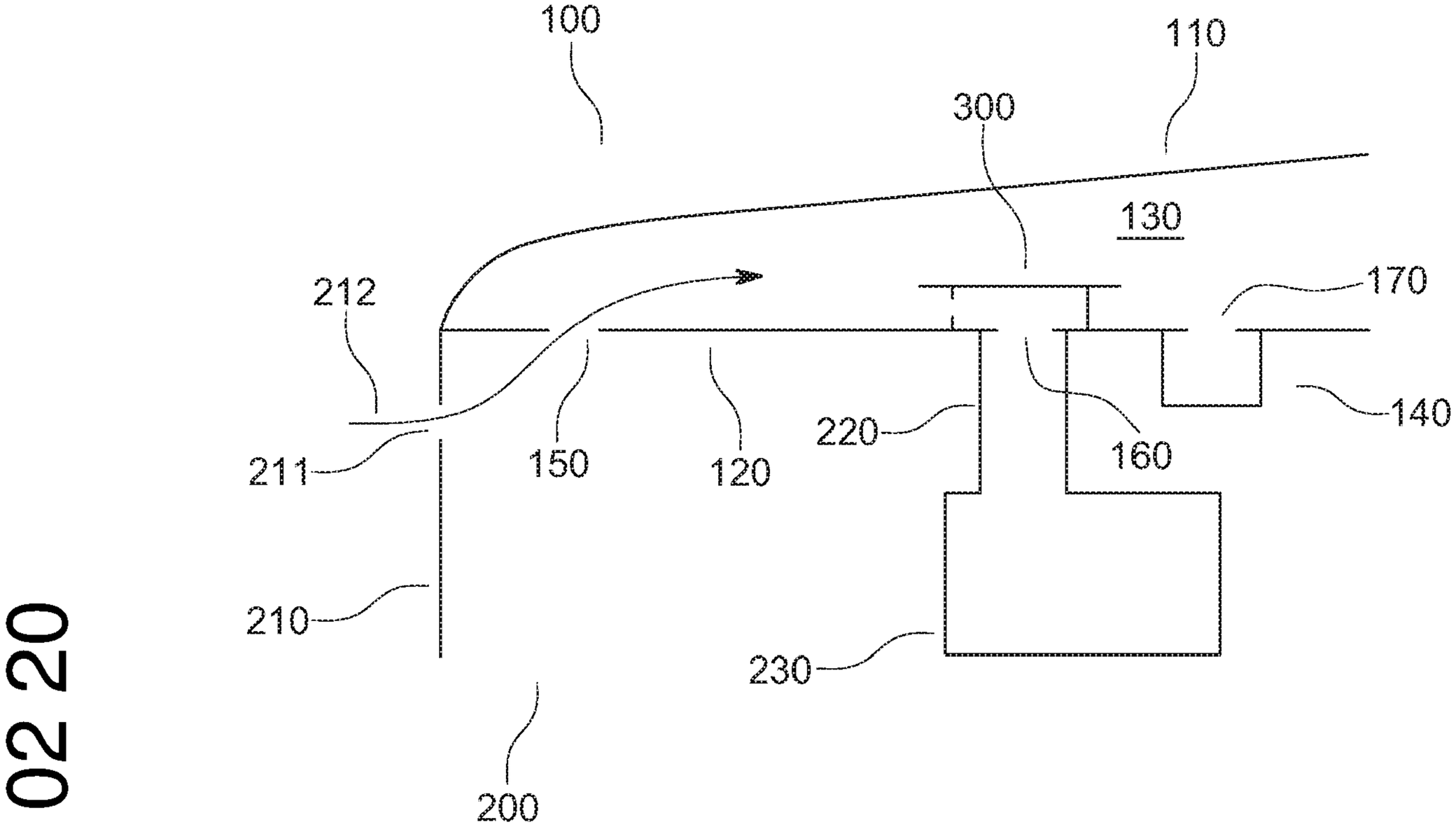

FIG. 3

13 02 20

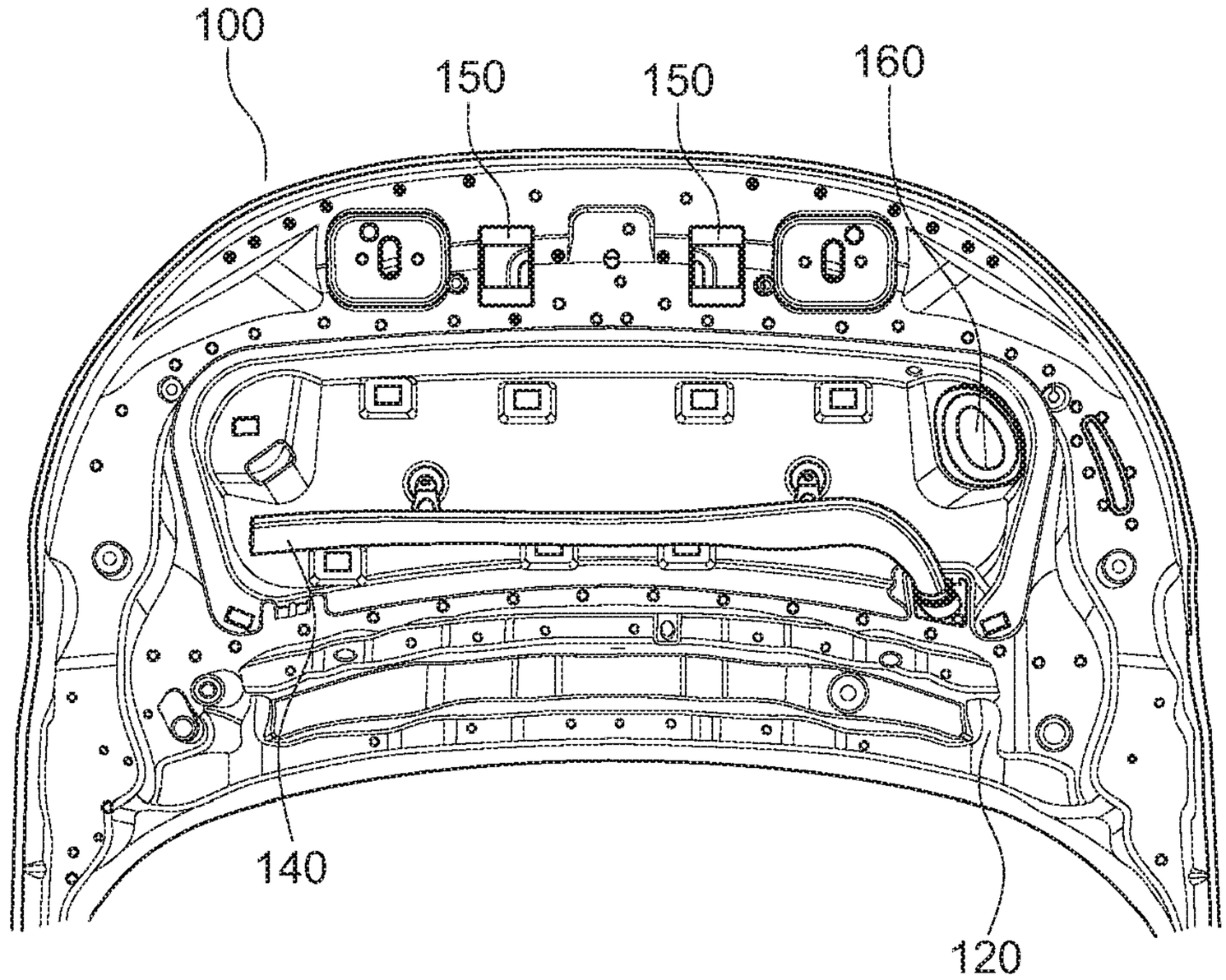

FIG. 4

02 20
13

13 02 2020

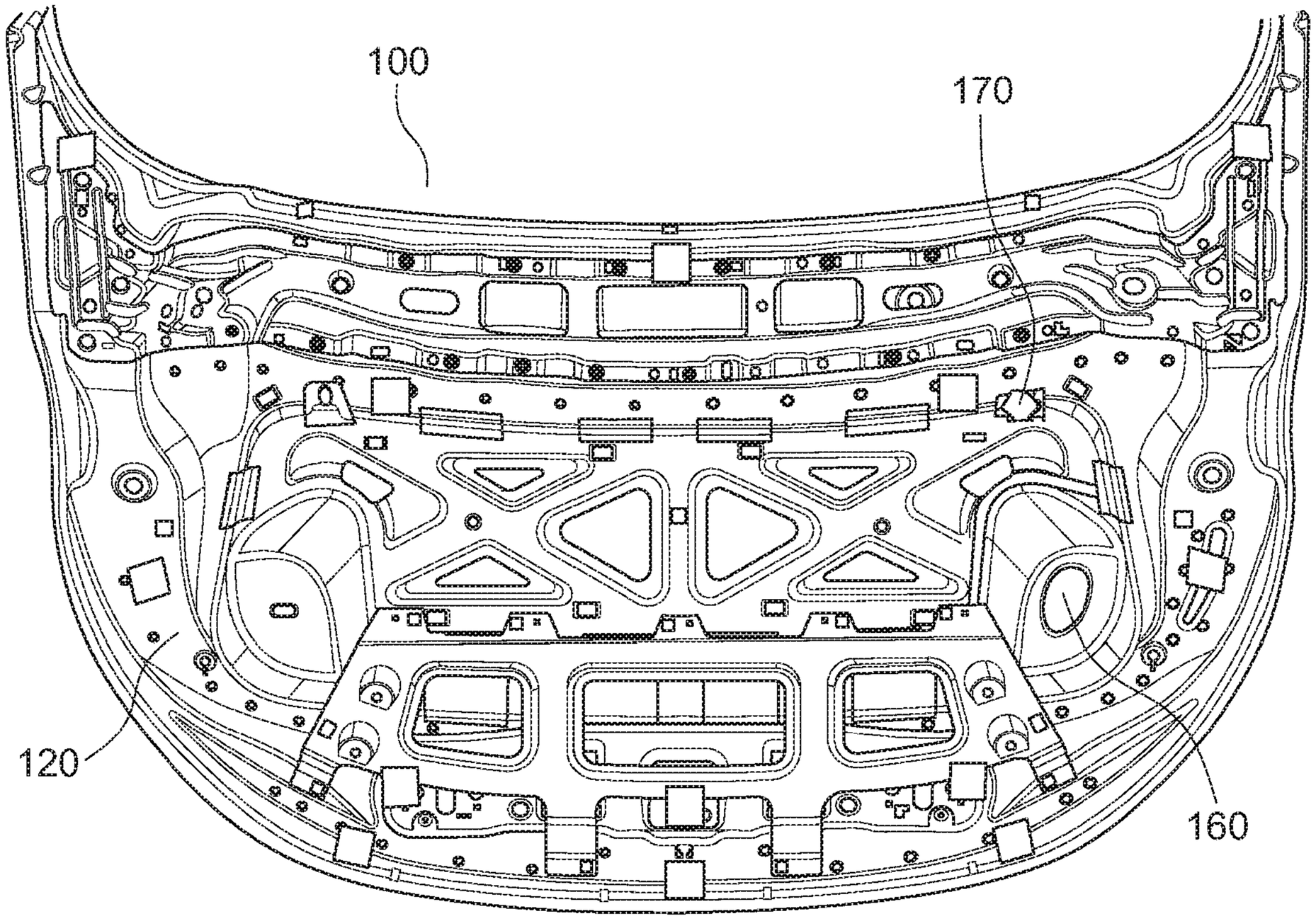

FIG. 5

13 02 20

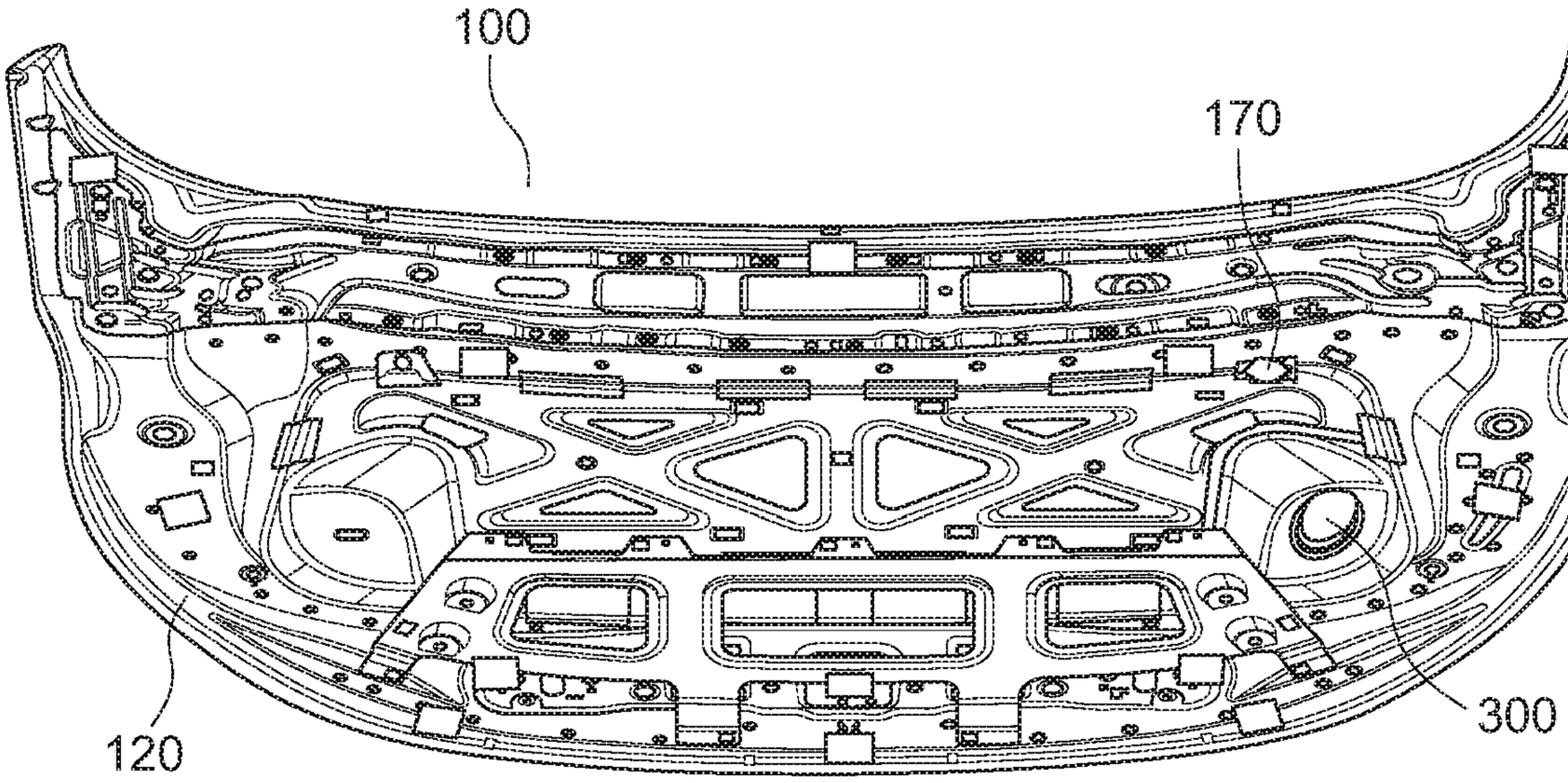

FIG. 6

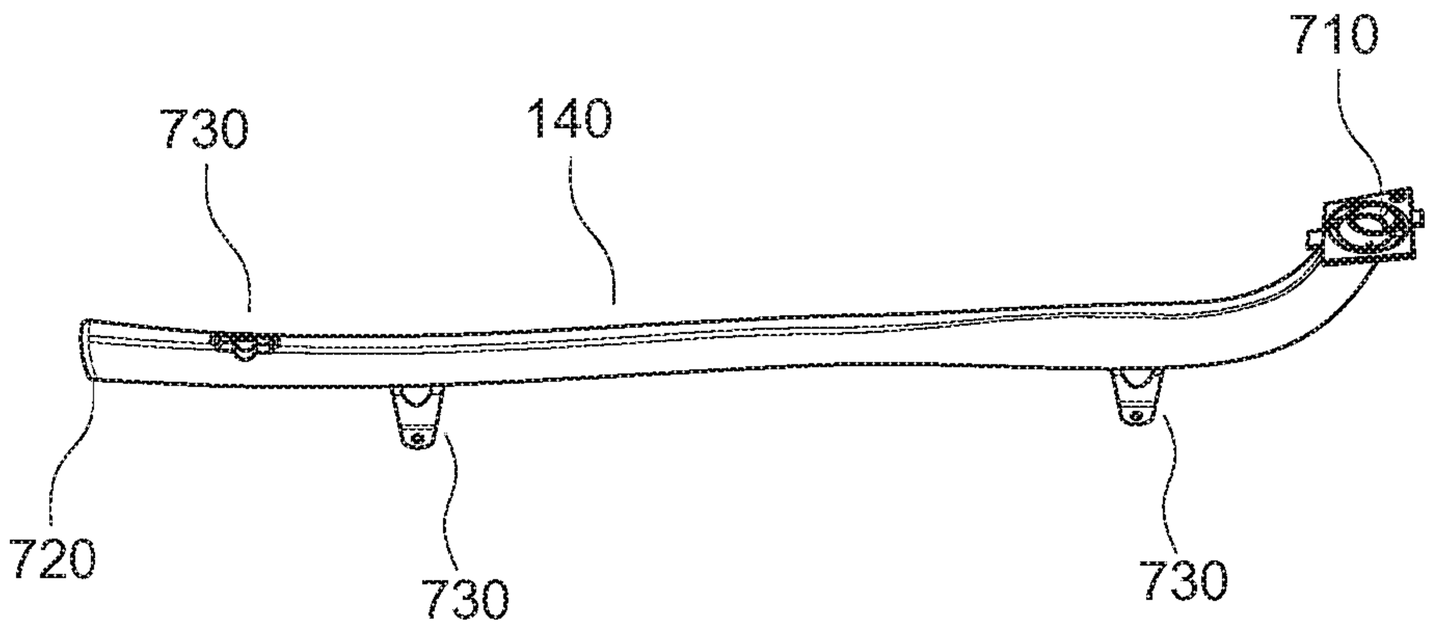

FIG. 7

20 13 02

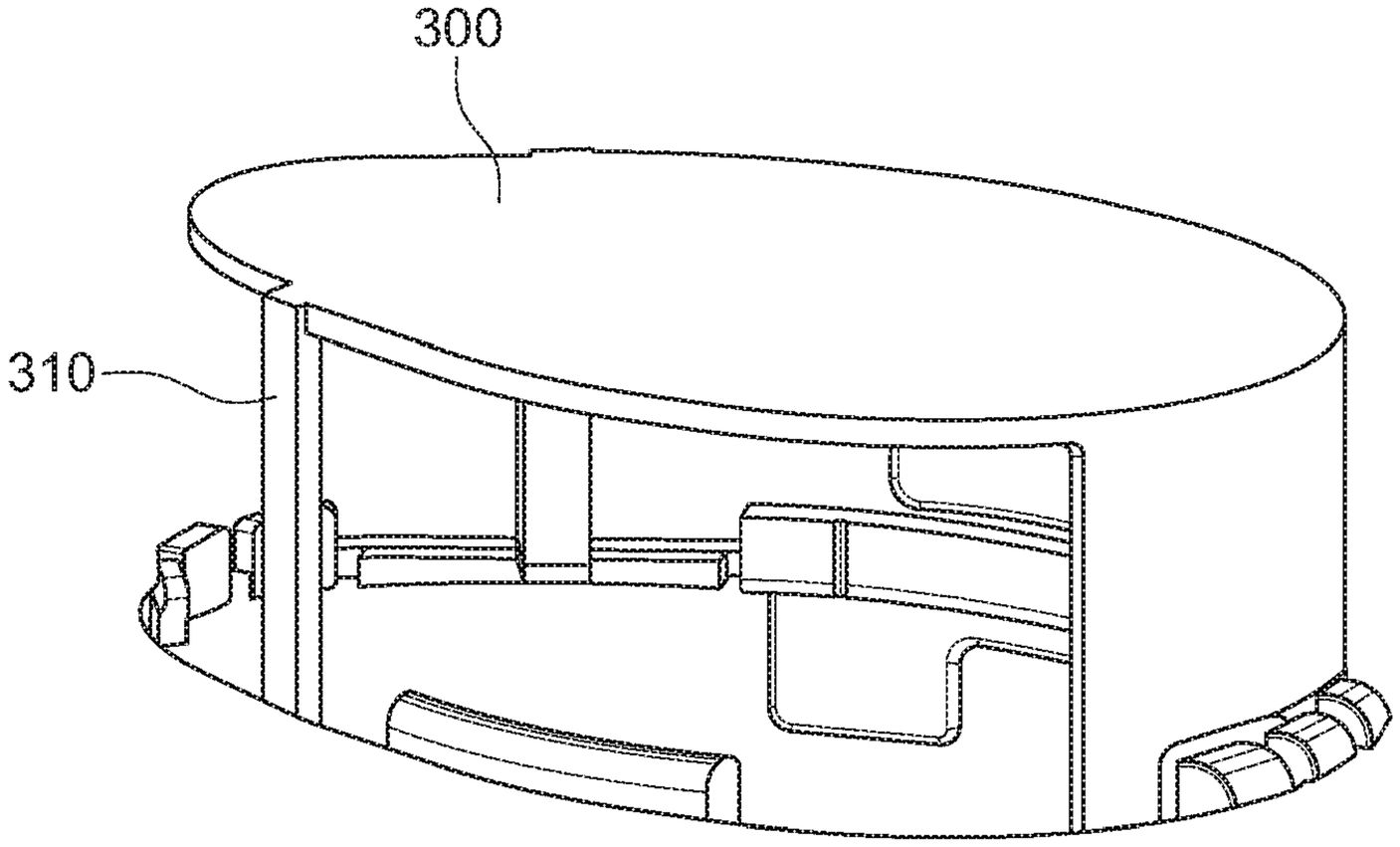

FIG. 8

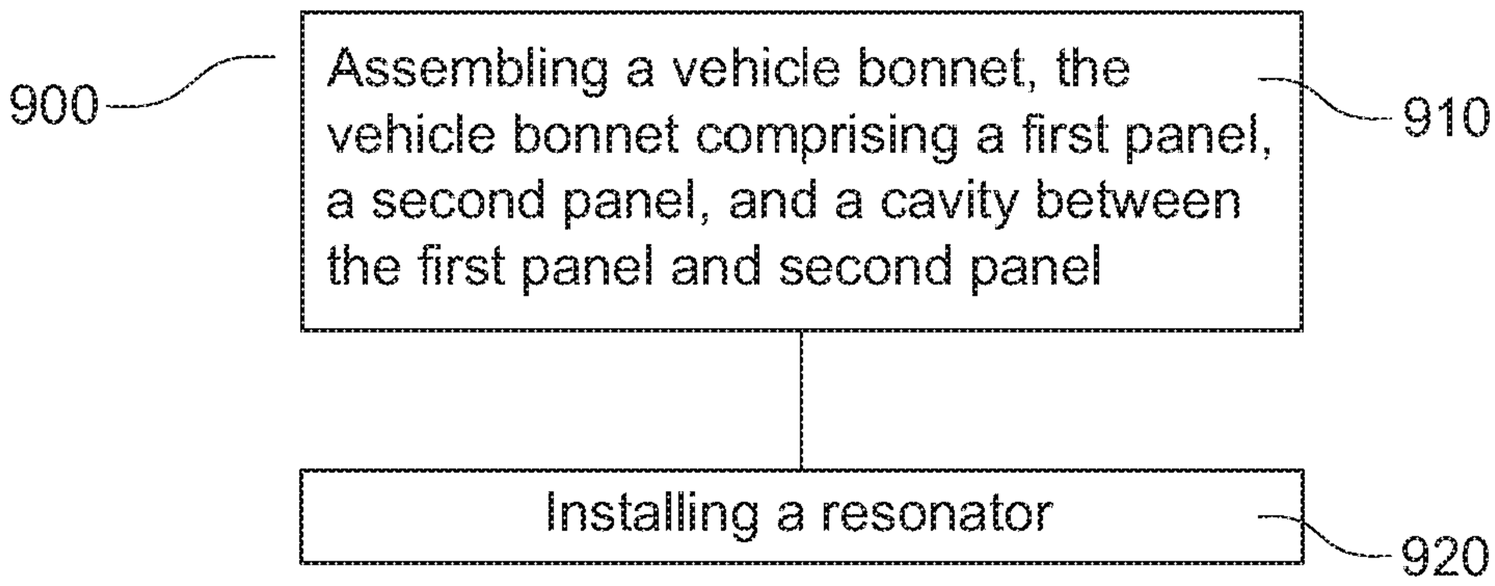

FIG. 9

20 13 02

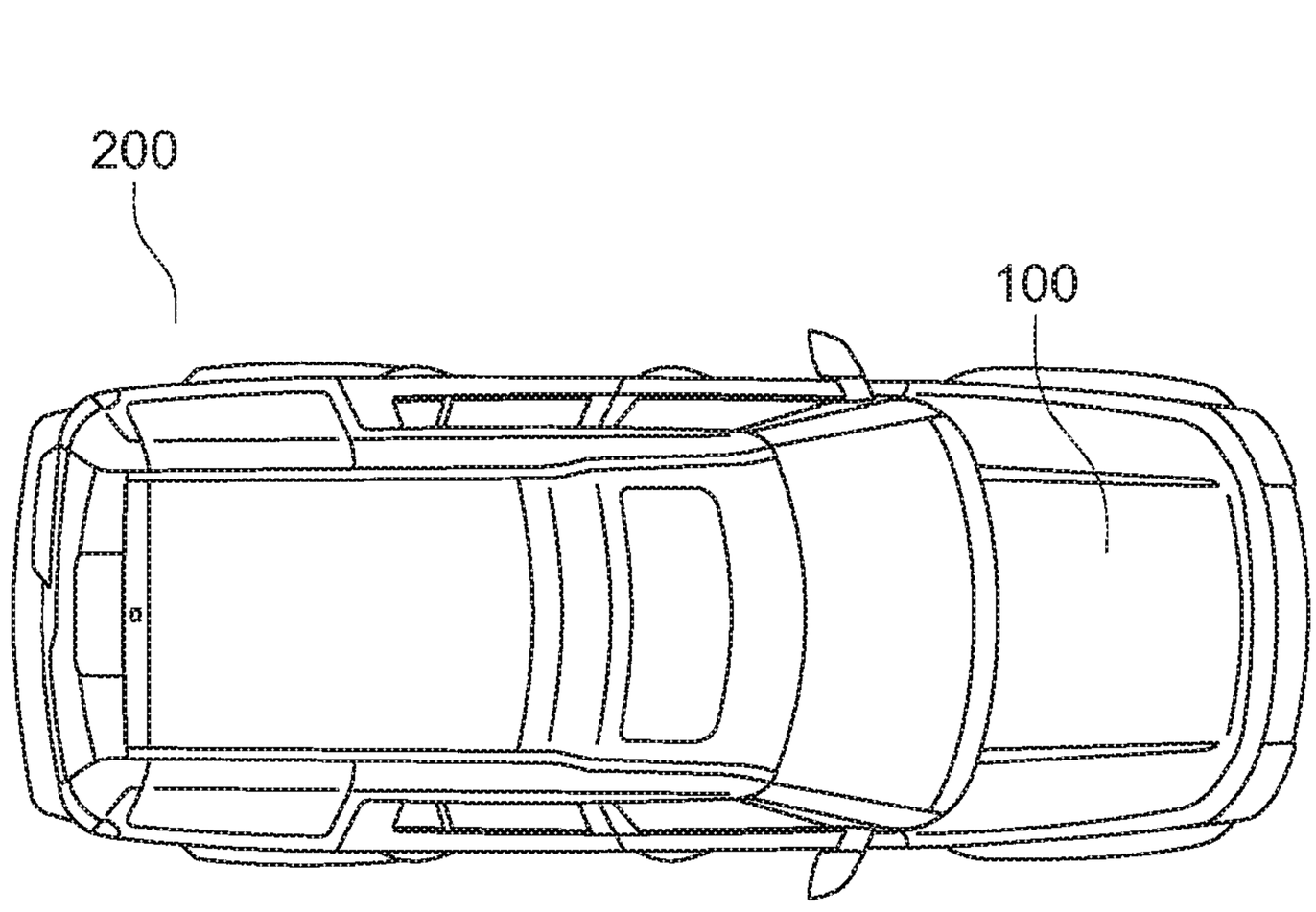

FIG. 10

A VEHICLE BONNET, A METHOD OF ASSEMBLING A VEHICLE BONNET AND A VEHICLE COMPRISING A BONNET

TECHNICAL FIELD

The present disclosure relates to a vehicle bonnet, a method of assembling a vehicle bonnet and a vehicle comprising a bonnet. In particular, but not exclusively, it relates to a vehicle bonnet, a method of assembling a vehicle bonnet and a vehicle comprising a bonnet where acoustic waves within the cavity of the bonnet are attenuated.

BACKGROUND

It is known for a vehicle bonnet to comprise multiple surfaces, where a cavity is provided between the surfaces. Intake air may be directed into the cavity and into an air intake duct via an orifice in the bonnet where the air intake duct leads to the intake of the engine of the vehicle. Acoustic waves are emitted by the engine and travel back through the air intake duct into the cavity. In some circumstances, the bonnet cavity resonates causing amplification of acoustic waves originating from the engine, such as combustion noise. The amplification of engine noise may be undesirable to a user of the vehicle. Additionally, structural modes of the bonnet surface may be excited by acoustic waves propagating upstream from the engine through the intake duct(s) and orifice to the bonnet surface. The orifice may be proximate to an area of the bonnet surface that is not as stiff as other areas of the bonnet surface, and this prevents a range of acoustic wave frequencies from the engine (e.g. 40-200Hz) from being absorbed. This causes the bonnet surface to vibrate. This vibration of the bonnet may cause an “audible boom”, which may be undesirable to a user. The resonance and the “audible boom” may particularly occur in bonnet cavities where a middle or intermediate layer has been removed from the cavity of the bonnet.

It is an aim of the present invention to address one or more of the disadvantages associated with the prior art.

SUMMARY OF THE INVENTION

Aspects and embodiments of the invention provide a vehicle bonnet, a method and a vehicle as claimed in the appended claims.

According to an aspect of the invention there is provided a vehicle bonnet comprising a first panel, a second panel, and a cavity between the first panel and the second panel, wherein the cavity is configured to receive intake air; and a resonator, wherein the resonator is arranged to attenuate acoustic waves within the cavity.

This provides the advantage that acoustic waves within the cavity can be attenuated so as to eliminate undesirable noise that would otherwise be heard by a user of the vehicle.

The resonator may be a quarter wavelength resonator. The quarter wavelength resonator may be arranged to attenuate acoustic waves with a frequency associated with a resonant mode of the cavity.

The resonator may be in fluid communication with the cavity.

The second panel may comprise a resonator aperture. The resonator aperture provides a passage between the resonator and the cavity for fluid communication.

The second panel may comprise an intake air aperture arranged to receive intake air from the environment external to the vehicle bonnet.

The resonator aperture may be located downstream of the intake air aperture with respect to a flow of intake air through the cavity in use. Alternatively, the resonator aperture may be located upstream of the intake air aperture with respect to a flow of intake air through the cavity in use.

The resonator may be attached to the second panel.

The resonator may be located externally of the cavity.

The resonator may have an open end and a closed end. The length of the resonator extending between the closed end and the open end may be arranged to attenuate acoustic waves with a frequency of 100Hz or 75Hz.

The second panel may comprise an orifice, the orifice being arranged to provide a passage for intake air to travel from the cavity into an air intake duct of an engine of a vehicle when the bonnet is attached to the vehicle.

The vehicle bonnet may additionally comprise an insert. The insert may be arranged to disrupt air pressure pulsations entering the cavity from the air intake duct.

The insert may overly the orifice.

According to another aspect of the invention there is provided a method of assembling a vehicle bonnet, the vehicle bonnet comprising a first panel, a second panel, and a cavity between the first panel and the second panel, wherein the cavity is arranged to receive intake air. The method additionally comprises installing a resonator, wherein the resonator is configured to attenuate acoustic waves within the cavity.

This provides the advantage that a resonator that can attenuate acoustic waves within the cavity of a vehicle bonnet can be easily fitted to the bonnet during assembly of the vehicle.

According to a further aspect of the invention there is provided a vehicle comprising the vehicle bonnet of any preceding paragraph.

This provides the advantage that the resonator in the vehicle attenuates acoustic waves within the cavity which would otherwise be heard by users of the vehicle and would be undesirable for the users of the vehicle to hear.

The vehicle bonnet may be for attenuating acoustic waves.

Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or

features of any embodiment can be combined in any way and/or combination, unless such features are incompatible. The applicant reserves the right to change any originally filed claim or file any new claim accordingly, including the right to amend any originally filed claim to depend from and/or incorporate any feature of any other claim although not originally claimed in that manner.

BRIEF DESCRIPTION OF THE DRAWINGS

One or more embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 illustrates an example of a vehicle bonnet;
Figure 2 illustrates an example of a vehicle bonnet attached to a vehicle;
Figure 3 illustrates an example of a vehicle bonnet attached to a vehicle;
Figure 4 illustrates an example of a vehicle bonnet;
Figure 5 illustrates an example of a vehicle bonnet;
Figure 6 illustrates an example of a vehicle bonnet;
Figure 7 illustrates an example resonator for a vehicle bonnet;
Figure 8 illustrates an example insert for a vehicle bonnet
Figure 9 illustrates an example method of assembling a vehicle bonnet; and
Figure 10 illustrates an example vehicle comprising a bonnet.

DETAILED DESCRIPTION

A vehicle bonnet in accordance with an embodiment of the present invention is described herein with reference to the accompanying Figure 1.

With reference to Figure 1, an example of a vehicle bonnet 100 in which embodiments of the invention can be implemented is shown.

Figure 1 illustrates a vehicle bonnet 100 having a first panel 110 and a second panel 120, where there is a cavity 130 between the first panel 110 and second panel 120. The vehicle bonnet 100 comprises a resonator 140 that is configured to attenuate acoustic waves within the cavity 130.

In this example, an air intake aperture 150 is provided in the second panel 120. The air intake aperture 150 is arranged to receive intake air from the environment external to the bonnet 100. In use, intake air travels through the cavity 130 and out through an orifice 160 to an engine of the vehicle. A resonator aperture 170 is provided that provides a passage between the resonator 140 and the cavity 130. The resonator aperture 170 in this example provides a passage between the resonator 140 and the cavity 130 for fluid communication between the cavity 130 and the resonator 140. Fluid communication in this context means that intake air can travel between the cavity 130 and the resonator 140. The resonator 140 is arranged to attenuate acoustic waves that are within the cavity. Acoustic waves enter the cavity via orifice 160 are from the engine of the vehicle when the bonnet 100 is connected to the vehicle.

In this example the resonator 140 is a quarter wavelength resonator.

A quarter wavelength resonator is typically a tube with an open end that in this example is connected to resonator aperture 170 and also has a closed end at the other end of the tube. In this example the quarter wavelength resonator 140 is shown in cross-section. The length of the tube extends in a generally perpendicular direction to the plane of the cross-section shown in Figure 1. In other examples the resonator 140 may extend in a different direction to that shown in Figure 1. For illustration purposes only, resonator 140 is shown as having a rectangular cross-section in Figures 1-3. Typically the resonator 140, such as a quarter wavelength resonator, has a circular/rounded cross-section, due to the tube of the resonator 140.

The frequency of acoustic waves which the quarter wavelength resonator 140 significantly attenuates is controlled by the length of the quarter wave tube.

When an incoming acoustic wave travels past the open end of a quarter wavelength resonator at the open end of the tube, the energy of the wave may split and may partially travel past the opening and also partially travel to the closed end of the tube. When the partial wave hits the closed end of the tube it reflects and travels back to the open end. The reflected partial wave will then meet the incoming acoustic wave which will have progressed during the time that the reflected partial wave has travelled to the closed end and back. If the reflected partial wave is in antiphase with the part of the incoming acoustic wave it meets, the two waves will destructively interfere, causing attenuation of the acoustic wave. It is known to provide a quarter wavelength resonator at a junction within a duct; the incoming acoustic wave travels

through the duct and is attenuated at the junction. In examples illustrated, the quarter wavelength resonator is provided at a resonator aperture 170 of the cavity 130, and the incoming acoustic wave is within the cavity 130.

For a quarter wavelength resonator, the length of the tube is typically designed to be quarter of the wavelength that is targeted for attenuation.

It has been found that a vehicle bonnet as illustrated in Figure 1 may have acoustic modes in which the acoustic waves entering from orifice 160 cause the cavity 130 to resonate causing amplification of acoustic waves originating from the engine. This may be undesirable to a user of the vehicle.

By designing a quarter wavelength resonator to attenuate acoustic waves with a frequency associated with an acoustic mode of the cavity 130, the quarter wavelength resonator can attenuate the amplified acoustic waves of the acoustic mode of the cavity 130, thereby reducing the noise heard by a user of the vehicle.

The location of the resonator aperture 170 and the open end of the quarter wavelength resonator may be placed so as to coincide with a measured or simulated location within the cavity where a hotspot (also known as pressure point) of high amplitude resonant acoustic waves occur within the cavity 130. For example a hotspot of high amplitude waves may be found by using computational-aided engineering (CAE). In some examples, acoustics and noise modelling software may be used to find hotspots of high amplitude acoustic waves. In the example in Figure 1, the resonator aperture 170 is located downstream of the air intake aperture 150 with respect to a flow of intake air through the cavity 130 in use. In other examples the resonator aperture 170 is located upstream of the air intake aperture 150 with respect to a flow of intake air through the cavity 130 in use.

In some examples the length of the resonator 140 extending between the closed end and the open end is configured to attenuate acoustic waves with a frequency of 100 Hz or 75 Hz. In these examples the length of the quarter wave tube may be 805mm to attenuate 100Hz or 1120mm to attenuate 75Hz. The length of the quarter wave tube required may also be affected by the temperature of the air entering the cavity 130 in use as temperature affects the speed of sound.

Figure 2 illustrates an example in which the vehicle bonnet 100 is attached to a vehicle 200 and is closed. The grille 210 allows air to pass through grille aperture 211 and into the air intake aperture 150. Intake air then travels into the cavity 130. Arrow 212 illustrates an example flow path of intake air into cavity 130. Intake air in cavity 130 then travels through orifice 160, into the air intake duct 220. From the air intake duct 220, intake air travels into the internal combustion engine 230. As described above, acoustic waves emitted by the engine 230 may travel back through the air intake duct 220 and into the cavity 130. In the example provided in Figure 2, the resonator 140 is configured to attenuate acoustic waves within the cavity 130.

Figure 3 illustrates an example in which an insert 300 is provided in the vehicle bonnet 100. For illustration purposes, a gap is shown in insert 300 in Figure 3 to illustrate that intake air in the cavity 300 can enter air intake duct 220. It is to be understood that the insert 300 may be added or removed to the vehicle bonnet 100 before it is attached to the vehicle. The insert 300 comprises at least one surface which disrupts pressure pulsations emitted by the engine 230 which enter the cavity via the air intake duct 220. It has been found that without the insert 300, structural modes of the bonnet surface (e.g. first panel 110) are excited due to pressure pulsations propagating upstream from the engine 230 through air intake duct(s) 220 and the orifice 160 to the bonnet surface. The orifice 160 may be proximate to an area of the bonnet surface that is not as stiff as other areas of the bonnet surface, and this prevents a range of acoustic wave frequencies from the engine (e.g. 40-200Hz) from being absorbed. This causes the bonnet surface to vibrate. The vibrations of the bonnet surface (e.g. first panel 110) may cause an “audible boom” that is undesirable for a user of the vehicle. In a vehicle comprising an example bonnet of the present invention, the “audible boom” occurs at engine speeds of 2000-3000rpm. The “audible boom” may also occur at other engine speeds. The insert 300 prevents the pulsations from causing the first panel 110 to vibrate by disrupting the path of the pulsations from the intake duct 210 to the top panel 110, thereby reducing the “audible boom”. Without the insert 300, the pressure pulsations have a direct path to the first panel 110 from the orifice 160, causing the first panel 110 to vibrate.

Figure 4 illustrates an example of the vehicle bonnet 100 as viewed from below the second panel 120. In this example two air intake ducts 150, which may also be referred to as intake orifices, are provided and the resonator 140 is a quarter wavelength resonator. In this example the quarter wavelength resonator 140 is attached to the underside of the second panel 120

and is external to the cavity 130 which is not shown in Figure 4. The quarter wavelength resonator 140 is selectively attached to the underside of the second panel 120. It is to be noted that when the resonator 140 is removed an increase in amplitude of acoustic waves at resonant modes of the cavity 130 can be detected. This is undesirable for users of the vehicle. For example this can be detected by sensors placed within the vehicle bonnet cavity 130 and within the cabin of the vehicle 200.

As illustrated in Figure 4, the quarter wavelength resonator 140 extends substantially across the width of the vehicle bonnet 100. The quarter wavelength resonator in some examples is between 0.5 and 1.5m in length.

Figure 5 illustrates an example of the vehicle bonnet 100 viewed from above with the first panel 110 removed. As illustrated in Figure 5, the orifice 160 and resonator aperture 170 are provided in the second panel 120.

Figure 6 illustrates an example of a vehicle bonnet 100 as viewed from above with the first panel 110 removed. In this example an insert 300 has been mounted above orifice 160 so as to overlie orifice 160. Insert 300 disrupts pressure pulsations that are emitted from orifice 160 when the bonnet 100 is attached to the vehicle 200 and the engine 230 is running.

Figure 7 illustrates an example of a resonator 140. In this example the resonator 140 is a quarter wavelength resonator. The quarter wavelength resonator 140 has an open end 710 and a closed end 720. The quarter wavelength resonator also has attachment means 730 for selectively attaching the quarter wavelength resonator 140 to the second panel 120.

Figure 8 illustrates an example insert 300 which is selectively mounted above orifice 160 in the vehicle bonnet. The insert 160 is designed so that an adequate amount of air can travel through orifice 160 to the engine 230 so that engine 230 is not choked when in operation. The insert 300 has at least one surface which disrupts pressure pulsations emitted from orifice 160 by the engine 230. One or more struts 310 may be provided to support the insert 300 above orifice 160 but to also enable air to travel through the orifice 160

Figure 9 illustrates an example method 900 in accordance with an embodiment of the invention. The method comprises in a first block 910 assembling a vehicle bonnet, the vehicle bonnet comprising a first panel, a second panel, and a cavity between the first panel and

second panel and in a second block 920 installing a resonator. The resonator may be selectively added and removed to the vehicle bonnet. The resonator may be configured to attenuate acoustic waves within the cavity as described herein.

Figure 10 illustrates an example vehicle 200 incorporating a vehicle bonnet 100 as described herein. The vehicle bonnet 100 comprises any of the features described herein and in particular comprises a first panel 110, a second panel 120 defining a cavity 130 and a resonator 140 wherein the resonator 140 is configured to attenuate acoustic waves within the cavity 130.

According to the examples provided, a vehicle bonnet 100 is provided that has a resonator 140. The resonator 140 is configured to attenuate acoustic waves within a cavity 130 of the vehicle bonnet 100. In particular, the resonator 140 may be configured to provide significant attenuation of acoustic waves at an acoustic mode of the cavity 130. An insert 300 may be provided to prevent an “audible boom” which would otherwise occur due to pressure pulsations hitting the first panel 110 causing it to vibrate, when the pressure pulsations are emitted from the orifice 160 by an engine 230. Therefore, the resonator 140 provides attenuation of acoustic waves due to acoustic modes of the cavity 130 which would otherwise be heard by a user of the vehicle, and the insert 300 prevents an “audible boom” due to the top panel 110 vibrating, which would otherwise be heard by a user of the vehicle.

It will be appreciated that various changes and modifications can be made to the present invention without departing from the scope of the present application.

The blocks illustrated in Figure 9 may represent steps in a method and/or sections of code in the computer program. The illustration of a particular order to the blocks does not necessarily imply that there is a required or preferred order for the blocks and the order and arrangement of the block may be varied. Furthermore, it may be possible for some steps to be omitted.

Although embodiments of the present invention have been described in the preceding paragraphs with reference to various examples, it should be appreciated that modifications to the examples given can be made without departing from the scope of the invention as claimed.

For example the air intake duct 150 may not be provided in the second panel 120 but may be provided in the first panel 110. Alternatively, intake air may enter the cavity in another way

besides an air intake duct 150. For example intake air may enter by a vent in the bonnet or a component external to the bonnet may take in intake air and the component may have an output within the bonnet.

In some examples orifice 160 is not provided, instead intake air enters the engine via an open end of the bonnet, e.g. the cavity 130 is open ended.

In some examples the resonator 140 is not provided externally of the cavity 130 and is provided within the cavity 130. In this example a resonator aperture 170 is not required.

In some examples the resonator 140 is not a quarter wavelength resonator. The resonator may be any suitable resonator or damper, such as a three-quarter wavelength resonator.

References to vehicle bonnet may also be understood to be referring to a vehicle hood.

Features described in the preceding description may be used in combinations other than the combinations explicitly described.

Although functions have been described with reference to certain features, those functions may be performable by other features whether described or not.

Although features have been described with reference to certain embodiments, those features may also be present in other embodiments whether described or not.

Whilst endeavoring in the foregoing specification to draw attention to those features of the invention believed to be of particular importance it should be understood that the Applicant claims protection in respect of any patentable feature or combination of features hereinbefore referred to and/or shown in the drawings whether or not particular emphasis has been placed thereon.

CLAIMS

1. A vehicle bonnet comprising:

a first panel, a second panel, and a cavity between the first panel and the second panel, wherein the cavity is configured to receive intake air; and

a resonator, wherein the resonator is arranged to attenuate acoustic waves within the cavity.

2. A vehicle bonnet as claimed in claim 1, wherein the resonator is a quarter wavelength resonator, wherein the quarter wavelength resonator is arranged to attenuate acoustic waves with a frequency associated with a resonant mode of the cavity.

3. A vehicle bonnet as claimed in claim 1 or claim 2, wherein the resonator is in fluid communication with the cavity.

4. A vehicle bonnet as claimed in any preceding claim, wherein the second panel comprises a resonator aperture, wherein the resonator aperture provides a passage between the resonator and the cavity for fluid communication.

5. A vehicle bonnet as claimed in any preceding claim, wherein the second panel comprises an intake air aperture arranged to receive intake air from the environment external to the vehicle bonnet.

6. A vehicle bonnet as claimed in claim 5, when dependent on claim 4, wherein the resonator aperture is located downstream of the intake air aperture with respect to a flow of intake air through the cavity in use.

7. A vehicle bonnet as claimed in claim 5, when dependent on claim 4, wherein the resonator aperture is located upstream of the intake air aperture with respect to a flow of intake air through the cavity in use.

8. A vehicle bonnet as claimed in any preceding claim, wherein the resonator is attached to the second panel.

9. A vehicle bonnet as claimed in claim 8, wherein the resonator is located externally of the cavity.

10. A vehicle bonnet as claimed in any preceding claim, wherein the resonator has an open end and a closed end, wherein the length of the resonator extending between the closed end and the open end is arranged to attenuate acoustic waves with a frequency of 100Hz or 75Hz.

11. A vehicle bonnet as claimed in any preceding claim, wherein the second panel comprises an orifice, the orifice being arranged to provide a passage for intake air to travel from the cavity into an air intake duct of an engine of a vehicle when the bonnet is attached to the vehicle.

12. A vehicle bonnet as claimed in claim 11, additionally comprising an insert, wherein the insert is arranged to disrupt air pressure pulsations entering the cavity from the air intake duct.

13. A vehicle bonnet as claimed in claim 12, wherein the insert overlies the orifice.

14. A method of assembling a vehicle bonnet, the vehicle bonnet comprising a first panel, a second panel, and a cavity between the first panel and the second panel, wherein the cavity is arranged to receive intake air; the method comprising installing a resonator, wherein the resonator is configured to attenuate acoustic waves within the cavity.

15. A vehicle comprising the vehicle bonnet of any of claims 1 to 13.

Intellectual Property Office

Application No: GB1818961.3 **Examiner:** Mr Gareth Bond

Claims searched: 1 to 15 **Date of search:** 25 April 2019

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1-6, 8,11, 14,15	US2881860 A (Ternes) See resonator chambers 49 and 61 in figure 1 and column 2 lines 53 to 69.
X	1,3, 5,8 ,11-15	US4778029 A (THORNBURGH) See figure 1 and column 2 lines 29 to 43.
X	1-3, 5,11, 14,15	GB2499506 A (JAGUAR LAND ROVER LTD) See figures, page 4 lines 27 to 30, and page 12 lines 14 to 19.
X	1-3,5, 8,9, 14,15	FR2886892 A1 (RENAULT) See acoustic device 45 in figure 1, and page 5 lines 3 to 6.
X	1,3, 5,11, 14,15	US2701024 A (THOMAS) See figure 2 and column 2 lines 14 to 42.
X	1,3, 14,15	KR 1020020044780 A (KIA MOTORS) See resonance chamber 21 in figures, and WPI abstract.
A	-	GB793340 A (DAIMLER BENZ) See the figure and page 1 lines 57 to 64. Disclosing the use of quarter wavelength pipes 7 and 8.
A	-	JP2003166689 A (TOKYO GAS CO) See paragraphs 5 to 7. Disclosing a quarter wavelength resonator used on an engine air intake.

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Intellectual Property Office

Worldwide search of patent documents classified in the following areas of the IPC
F02M
The following online and other databases have been used in the preparation of this search report
EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
F02M	0035/12	01/01/2006
F02M	0035/16	01/01/2006