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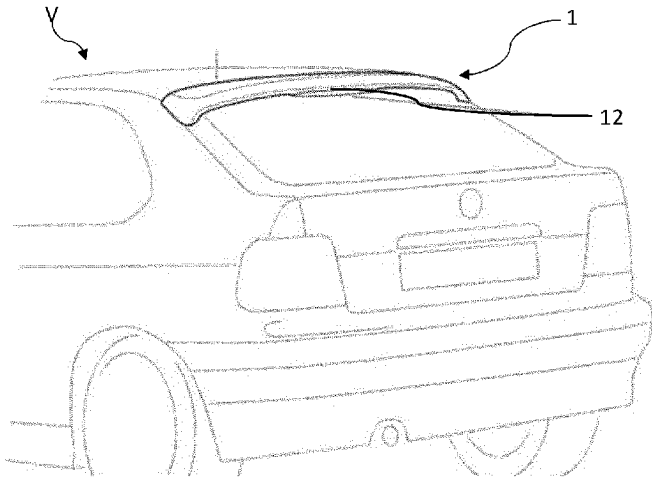


Fig.1

(57) Abstract: The present invention relates to a spoiler assembly for a vehicle, said spoiler assembly comprising: at least one cover part having an outer surface facing outside world and at least one lower part configured to be fixed on the vehicle; at least one antenna module having plurality of antennas; wherein the plurality of antennas are deployed on a dielectric substrate; the antenna module is situated between the cover part and the lower part.

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A VEHICLE SPOILER ASSEMBLY PROVIDED WITH AN ANTENNA MODULE HAVING PLURALITY OF ANTENNAS

FIELD OF THE INVENTION

[0001] The present invention relates to a spoiler assembly for a vehicle, specifically relates to the spoiler assembly situated on exterior of the vehicle, more specifically the spoiler assembly provided with at least an antenna module having plurality of antennas. Aspects of the invention also relate to the integration of the antenna module into the spoiler assembly, more specifically providing an enclosure for the antenna module, even more specifically constitution of a waterproof enclosure in a simple way. Aspects of the invention also relate to the antenna module having plurality of antennas working in different frequencies. Aspects of the invention also relate to telematics and cellular antennas, more specifically relate to Wi-Fi, V2X, 5G, 4G, 3G, 2G and satellite antennas and also UWB (ultra-wide-band) antennas. Aspects of the invention also relate to the antenna module mounted inside the spoiler assembly, wherein the antenna module comprises the plurality of antennas in a centralized aspect. Aspects of the invention also relate to a vehicle having a spoiler assembly.

[0002] In the conventional vehicles, antennas can be installed inside or on the glazing. Because antennas are not preferred to be installed in the visible area of glazing for not to disturb the view of the driver and/or the passengers, therefore limited antennas are found on vehicle glazing, such as broadcast antenna integrated with heating grid.

[0003] Thus, the shark-fin type antennas are generally considered as a viable place for most of the telematics antennas as well as satellite antennas. The advantage of shark-fin type antennas is that its position is ideal for antennas without any obstruction due to the metal body of the vehicle. Locating an antenna on the roof of the vehicle in the conventional manner requires a shark-fin type-like enclosure in order to effectively protect and hide from view of the driver. The antennas can also benefit from the roof of the car as a ground plane for these antennas. However, due to the aesthetic reason, the shark-fin size and shape is kept rather small, while hosting several antennas, i.e. usually a GPS antenna, two cellular antennas and maybe a Wi-Fi antenna. Further, the high data rates required by 4G/5G communication protocols may require multiple antennas to improve the MIMO (multi-input-multi-output) performance, meaning two shark-fin type antenna or a bigger shark-fin antenna. In addition, reception of satellite antennas also benefit from being located on the roof. Having more than

one cellular or satellite antenna requires either that the shark fin is increased in size or multiple roof-top antenna enclosures are provided.

[0004] However, such enclosures inevitably have a detrimental effect on the aerodynamics of the vehicle. Installing multiple shark-fin type antennas has the undesirable effect of further degrading the aerodynamic performance of the vehicle. Moreover, it is not just the aerodynamics, but also the environmental effect since aerodynamics plays a huge role in CO₂ emissions caused by the vehicles. Meaning, the use of shark-fin type antennas has not only advantages but also brings a huge challenge to the production and processing technology in order to deploy plurality of antennas. Such, the interference between the antennas as they are closely spaced can impact the performance of the antenna systems. In addition, since the shark-fin type antenna located over the metallic roof, it may heat up quickly because of the metallic surfaces and requires cooling means. Moreover, since the shark fin type antenna needs to be installed on the roof of the vehicle, vehicles equipped with a panoramic sunroof or vehicles with limited height may not be equipped with the shark fin type antenna. Therefore, the shark fin antenna cannot meet the complex installation requirements of the market. Furthermore, the shark-fin cannot be used for increasing new applications, such as V2X or future 5G due to the already limited space in the case of the shark fin type antenna already comprising plurality of antennas. There has to be a compromise on which antennas should be deployed in the shark-fin type antennas. In sum, shark-fin type antennas are not the ideal solution the industry looking for.

[0005] Further, if the antennas are placed in a less obtrusive place such as in another external component such as the wing/side mirrors, or under the roof then the reception is to some extent compromised and the attenuation problem with coaxial cable is exacerbated. In addition, such locations do not have sufficient volume for optimally configuring an antenna assembly. In the case of an under roof arrangement, to provide the necessary space for an effective antenna assembly would unacceptably compromise the headroom of the vehicle. It also forces a glass roof cover to be used which is detrimental to the mechanical properties of the vehicle. Alternative solution is therefore needed.

[0006] Antennas located inside the spoiler of the vehicles are known for a long time, the spoiler is an example for a non-metallic part provided in the exterior of the vehicle, usually provided on the rear side of the vehicle to provide aesthetic and/or aerodynamic improvements, however spoilers may also located on the other locations on the vehicle like

extending over the roof. Since the spoiler is made of non-metallic material which allows radio frequencies to be transmitted through, the spoiler is a good candidate for antenna deployment. Allocating antennas inside the spoiler seems to solve many disadvantages described above, mainly the space problem because the spoiler size is large enough to allocate antennas spaced apart. However, the spoiler has to be designed specifically to have multiple antennas located inside, i.e., the spoiler needs to have a specially designed housings inside for different antenna allocation, because antennas need to be distributed and to project in different directions to be able to radiate for achieving an all-around 360° coverage around the vehicle, i.e., coverage on the horizontal plane. Therefore, customization of the spoiler design is needed, which requires time and cost investments and on the other hand, such a distributed antenna system requires huge effort for the organization of cabling and protecting the antennas from environmental effects. Deploying antennas inside the spoiler has many advantages like similar or better performance compared to shark-fin solution since the antennas are located as high as shark-fin antennas and heating up of antennas and connected circuitry eliminated since spoiler material is not as heat conductive as metallic surfaces. Benefiting from these advantages and eliminating the investment cost can be achieved by providing antennas in a module requiring a compact volume. However the integration of such an antenna module into the spoiler will also require additional manufacturing steps which increases the costs. Designing a spoiler with a suitable housing for multiple antennas and achieving such without compromising the required integrity and strength of the spoiler is another problem for the spoiler or vehicle manufacturers. Such that, every vehicle manufacturer have different designs for their spoiler assembly to have required integrity and strength for the spoiler although the same spoiler design is used for different models of the said manufacturer.

[0007] In addition, vehicles economically priced do not require many antennas in contrast to premium vehicles, premium vehicles possess plurality of antennas like up to 10 antennas for different purposes. This requires usage of different antenna designs for every different spoiler design. Besides, an optimization process for antenna performance is also needed, unfortunately there is no plug&play solution for antennas and each antenna distributed around the spoiler needs to be tailor made for the specific design of the spoiler and the vehicle body. All these add up and require huge effort and time, meaning an increase in the production costs. Therefore, another alternative solution is needed.

[0008]As said, it is well known for years that spoiler of a vehicle can also be used as housing for vehicle antennas. For example, in JP2003273617, a wire automotive antenna integrated in the spoiler is described as an alternative to visible vehicle antennas on roof.

[0009]It is also known from US6927736, satellite antennas provided in automotive spoilers.

5 **[0010]**EP1843429A1 and GB2578597A and US20210387684 describe multiple antennas arranged in an automotive spoiler. The multiple antennas and radio unit receiver are provided with electronics and electrical device in spoiler. The space inside the spoiler is then limited and the number and the design of antennas to be arranged in the spoiler is then also limited.

[0011]CN113782970 and US10879600 and CN112803175 describe antennas provided on
10 printed circuit boards and the printed circuit boards are housed inside housings. CN113782970 provides slots on the printed circuit board to achieve isolation/decoupling between the antennas. CN112803175 requires multiple coaxial connection to each different antennas to provide isolation between antennas. In addition, CN113629409 provides a V2X antenna for spoiler, by having multiple antennas and multiple power dividers to reduce the
15 attenuation due to metallic vehicle body.

[0012]EP3347944 describes how a specific space is created for an antenna by providing a recess in the rear spoiler for a motor vehicle. It is explained that the recess for the antenna is provided outside of the rear spoiler since in the interior of the rear spoiler, there is not available space for the antenna. JP4871306 gives a clear explanation about how important is
20 the placement of antenna inside the vehicle in terms of the performance of the antennas and provides a solution to assure proper installation of the antennas.

[0013]CN110911803 describes how to integrate 5G and 4G antennas together in a limited space of shark-fin type antenna. It achieves such configuration by placing the antennas perpendicular to the printed circuit board and also by having a specific scheme of using 4 ×
25 5G antenna plus 2 × 4G antenna plus 2 × V2X antenna plus 1 × dual-frequency positioning antenna. Due to limited space, such perpendicular configuration of antennas could not be preferred for spoilers. Similarly, CN216648586 offers a box provided with multiple antennas to be placed in a vehicle spoiler and the antennas are needed to align vertically on the printed circuit board and where the height of the box is 50-70 mm, which is clearly not compatible
30 with every spoiler.

[0014] EP3375670 discloses a specifically designed receptacle for an electronics module that a flange region needed to be able to deploy an electronics module like an antenna module into the spoiler.

[0015] These above mentioned prior-arts propose to integrate different type of antennas in the vehicle spoiler. However, none of those presents a solution that minimizing the time and cost for a systematic approach to integrate multiple antennas, especially V2X, Wi-Fi, cellular antennas like 5G, satellites antennas, UWB antennas required by the most vehicle manufacturer for telematics communications, into an spoiler assembly of the vehicle in a cost efficient way, such that to mount the antennas into the spoiler like a plug&play solution or with less effort like a centralized cabling solution, to optimize the performance of the antenna based on its application, at the same time and where several antennas of different applications co-exist in the same spoiler assembly, and with structural integrity that the antennas protected from environmental effects and also ability of servicing the antennas without disregarding the spoiler, and also with efficient routing for the transmission lines coming out the antennas to reduce the weight of the cabling. The proposed prior art solutions mainly states/gives no detail about the integration that an antenna module placed inside a vehicle spoiler and even the ones with integration details include specifically designed housings/receptacles inside the spoiler for the antenna module, especially a certain height which is, as said, compromising the required integrity and strength of the spoiler and moreover increasing the integration cost which is one of the main causes behind the setback of advancement. Moreover, no information about protection of the antenna module from the environmental effects is given and in some prior art, to achieve such feature, a waterproof antenna box is required which means need for a bigger volume inside the spoiler.

[0016] Today, more and more antennas and different types of antennas are requested to be integrated in the spoiler assemblies, since the electromagnetic transmission, i.e., the signal is not attenuated like the metal surfaces. The need of diversity of the type of antennas working at high-frequency such as telematics antennas (e.g. cellular, satellite, V2X) and their powering lead to some issues such as:

- the position of the different telematics antennas in order to maximize their performances regardless of the vehicle body
- how the antennas of different applications can co-exist in a centralized location inside the spoiler

- positioning/integration of antennas in a small module to achieve a universal design to fit in spoiler assembly without compromising the performance.

[0017] It is known from WO2023281060 a spoiler assembly. Said assembly comprises a spoiler housing a plurality of antenna elements; wherein the plurality of antenna elements are arranged on a surface of the spoiler housing, and the said antenna elements working at different range of frequencies. The plurality of antenna elements is situated between a cover part and a lower part of the spoiler housing.

[0018] US2021387684 discloses a coaxial keg connector comprising a main body made of plastic and having a first inlet port and a second inlet port receiving a stem. A coaxial outlet comprises an outer outlet port in communication with the first inlet port and an inner outlet port in communication with the second inlet port. The stem comprises a tubular body with a main axis with an inlet and a connector for attachment to the keg at one end. The second end of the stem opposite to the first end has an outlet in fluid communication with the inner outlet port and comprises a ball joint rotatably mounted in and sealed with respect to the main body so as to be rotatable about the main axis of the tubular body and rotatable to a limited extent about axes perpendicular to the main axis.

[0019] GB2461896 discloses an antenna assembly and a method of its installation comprises an antenna on a flexible circuit board mounted on the front surface of a support structure formed of dielectric material. The rear surface of the support structure includes at least one mounting element extending away from the rear surface. The mounting element is used to secure the antenna in a spaced manner relative to a motor vehicle body and a signal cable extends through the support and is connected to the circuit board. The front surface of the support may be curved to conform to the space available and for a constant gap between the antenna and the vehicle body. Buttresses and bump stops and a foam sealing strip may be arranged between the antenna and an external vehicle component such as a bumper. The support structure may be formed as a one piece moulding which includes web, reinforcing ribs, fins and buttresses. The flexible circuit board may be covered and sealed by a film of material secured to the board by an adhesive and/or fasteners. The signal cable may extend into the body of the vehicle to be connected to an amplifier which is in the proximity of the antenna assembly.

SUMMARY OF THE INVENTION

[0020] The present invention provides a spoiler assembly for a vehicle, especially a spoiler assembly provided on the exterior of the vehicle, said spoiler comprising at least one cover part and at least one lower part, and at least one antenna module comprising a plurality of antennas deployed on a dielectric substrate, wherein the dielectric substrate may be a regular printed circuit board and the antenna module is placed between the cover part and the lower part of the spoiler. The cover part may be the external surface of the spoiler functioning as the aesthetic and/or aerodynamic part of the spoiler. The lower part facilitates the fixation of the cover part to the vehicle by comprising fixation means and also structural features to ensure the structural integrity of the spoiler assembly. The assembly process of the cover part and the lower part provides an enclosure for the antenna module. The enclosure encloses the antenna module such that the volume where the antenna module located is preferably waterproof which will be described below.

[0021] Most of the spoiler assemblies having at least one cover part and at least one lower part assembled together by different processes such as gluing, welding or with double sided adhesive tapes and due to cost and structural integrity reasons, such spoiler assemblies have free space in the inside of the spoiler, that means the spoiler is a shallow structure that there is free space inside. When the cover part of the spoiler joins to the lower part of the spoiler, it is usually the lower part which satisfies the mechanical integrity of the spoiler assembly.

The present invention takes advantage of the said spoiler feature and allocates the antenna module into the free space inside the spoiler. The assembly process of the cover and lower part of the spoiler itself provides an enclosure to the antenna module. By providing a watertight sealant around the periphery of the enclosure, the volume where the antenna module is enclosed, is provided to be waterproof. Thereby the antenna module is protected from the environmental effects to ensure the longevity. More preferably the lower part constitutes the free volume available for an antenna module and the present invention proposes deploying an antenna module that can fit into the said free space and taking advantage of the assembly process of the lower part and the cover part.

[0022] The present invention provides such said waterproof enclosure without adding complex or extra manufacturing steps, therefore decreasing the cost of integration. In further embodiments of the present invention, similar approach is followed for the integration of the connection cables for the antenna module.

[0023] The antenna module of the present invention comprising plurality of antennas required by the major automotive manufacturers is a compact and centralized module that fits into the said free space. The plurality of antennas may be any combinations of satellite antennas, telematics antennas including cellular antennas like 4G, 5G and V2X antennas and the Wi-Fi antennas, UWB antennas arranged to co-exist in the spoiler assembly while keeping their better performances, i.e., without compromising the functioning and efficiency required by the common standards. The dielectric substrate and also the antennas are placed inside the spoiler and therefore, the antenna module comprising the satellite antennas, telematics antennas including cellular antennas and V2X antennas, UWB antennas are arranged to be located in the spoiler assembly, i.e., the antennas are located at the uppermost position of the vehicle, meaning the effect of the metallic vehicle body is minimized. Such arrangement provides a simple integration solution for mostly required antennas by the vehicle manufacturers, as well as allows the optimum usage of the spoiler assembly volume for antenna integration.

[0024] Advantageously, in different embodiments, the antenna module may comprise plurality of antennas working at least two different range of frequencies. Thus, the antennas can be configured to receive a range of different signal types or to be configured in an array to provide better transmission or reception capabilities. For example, the plurality of antennas may include a first antenna configured to receive signals in a first frequency band, a second antenna configured to receive signals in a second frequency band, a third antenna configured to receive signals in a third frequency band, a fourth antenna configured to receive signals in a fourth frequency band and so on. Thus, the antennas can receive different signal types located in different frequency bands. For example, the antennas may include at least one of a 2G, 3G, 4G (LTE), 5G, GNSS, V2X, Wi-Fi, UWB and SDARs antenna. Therefore, the antenna module of the present invention provides a centralized antenna solution for antennas required by many vehicle manufacturers as standard. With such a single antenna module comprising the most standard antennas required by the manufacturers, it is provided that the necessary cabling for the antenna connection is minimized such that it may improve reducing the weight of the vehicle, therefore improving efficiency. In addition to the efficiency point of view, such an antenna module located inside the spoiler may also improve recyclability of the spoiler assembly since the whole electronic parts are gathered in one piece.

[0025] Another advantage of the present invention is that since the antenna module is located around the non-metallic surroundings, the vehicle metallic body does not interfere with the performance of the antennas. Therefore, the antenna module of the present invention provides an universal solution for almost every vehicle on the market, henceforth the antenna module of the present invention provides a practical plug&play solution for vehicles having a spoiler assembly, and eliminated complex tailor-made antenna solutions which costs time and money.

[0026] Another advantage of the present invention is that the plurality of antennas formed on a dielectric substrate are covered by the spoiler itself. The advantageous part of the present invention is that the spoiler protects the antennas. In addition, the antenna module fits in the spoiler without needing a specially designed housing, meaning less structural modifications to integrate the antenna module, therefore the integration of the antenna module can be achieved effortlessly without needing specific measures since the enclosure provides water and dust proof volume. This allows the manufacturer to be able work more flexible, since the antenna module already fits into existing volume of the spoiler without too much constraints. Further, this arrangement allows high data throughput and connectivity to be achieved without compromising the cabin space or the appearance of the vehicle.

[0027] Having plurality of antennas formed on the dielectric substrate inside the spoiler allows providing an antenna module with common required antennas in one place and the antennas to be suitably configured to provide the necessary data throughput and bandwidth requirements required of modern communication standards such as satellite antennas, cellular antennas and telematic (e.g. 2G, 3G, and 4G (LTE) and 5G), GNSS and V2X or Wi-Fi or UWB antennas in combination with radio broadcast antennas located at another location inside the spoiler or another location of the vehicle, working at lower frequencies, with little or no aerodynamic penalty that would otherwise be incurred if the antennas were arranged elsewhere on the vehicle, for example in a conventional roof-top enclosure. Thus the present invention provides a solution of one for all.

[0028] One of the advantage of the antenna module as proposed in the present invention, is that it allows the co-existence of all described above antennas with the radio broadcast antennas, including AM/FM/DAB/TV, as such these antenna can be made of wire or foil.

[0029] The antennas and the module may be produced as a pre-fabricated module and placed inside the spoiler assembly of the vehicle. Such configuration of the present invention

eliminates the optimization of the antennas according to car body or etc. and ensures the optimum performance for the antennas. Number of antennas on the module may be arranged according to requirements of the vehicle manufacturer and/or according to specific country regulations and/or by having more than one module provided in the spoiler assembly
5 improves the quality as described below.

[0030] In some embodiments, at least two antenna module are placed inside the spoiler assembly. By this embodiment, specifications of premium vehicles are achieved, i.e., better coverage and better performance with more antennas. In a version of this embodiment, at least two antenna module are placed inside the spoiler, each one on each lateral side of a
10 spoiler, respectively. In these embodiments the modules may not necessarily be the same, they may comprise different antennas, for example only one of them may have a satellite antenna and the others may not or vice versa or any other combination of antennas. As mentioned above and will be detailed below, the antenna module of the present invention can be placed in the spoiler assembly without the need for a specific design for it.

[0031] The present invention allows spoilers to be designed as such without bearing in mind the antennas because the antenna module can fit into the spoiler like a plug&play solution. Furthermore, since none or less modifications needed for the integration of the antenna module, and the centralization of common required antennas in one module allows less cable harness, and the universality of the antenna module that fits almost any vehicle allows a
15 higher quality product with less costs. One further advantage of the present invention is that in the case of a service requirement, the antenna module is easily accessible as a whole for replacement, or repair or etc. compared to the distributed antenna systems used in vehicles.

[0032] In another aspect of the present invention provides a vehicle including a spoiler assembly as hereinbefore described. Preferably, the vehicle includes a transceiver or a control
20 unit coupled to the antennas. The transceiver/control unit may be included in the spoiler assembly or located elsewhere in the vehicle.

Brief Description of the Drawings

[0033] The invention will now be described further, by way of examples, with reference to
30 the accompanying drawings, wherein like reference numerals refer to like elements in the various figures. These examples are provided by way of illustration and not of limitation. The

drawings are a schematic representation and not true to scale. The drawings do not restrict the invention in any way. More advantages will be explained with examples.

[0034] **Fig.1** illustrates an example of the concept of the spoiler assembly, and **Fig.2** illustrates a schematic view of the antenna module, while **Fig.3** illustrates a cross-section of one of the examples of enclosures in the spoiler assembly and **Fig.4** illustrates the same from another perspective. **Fig.5** illustrates a perspective view of the spoiler assembly in a particular embodiment. **Fig.6** and **Fig.7** illustrate the connection fixing means in different embodiments of the spoiler assembly. **Fig.8** shows part of the enclosure for better understanding, for simplicity the connections from antennas to the connection fixing means is not shown. **Fig.9** and **Fig.10** illustrate exploded views of the spoiler assembly, where in **Fig.10** the lower part comprises more than one sub-parts. **Fig.11** illustrates the top view of the lower part in a particular embodiment where the spoiler assembly comprises two antenna modules and **Fig.12** illustrates an enlarged view of the detail A' in **Fig.11** with and without the cables and **Fig.13** illustrates an enlarged view of the detail A'' in **Fig.11** with and without the cables. **Fig.14** illustrates the bottom view of the spoiler assembly, especially the lower part in a particular embodiment and **Fig.15** illustrates the exploded view of bottom of spoiler assembly.

[0035] The elements illustrated in the figures are numbered as follows:

- 1. Spoiler assembly
- 11. Lower part
- 111. Rib
- 12. Cover part
- 13. Enclosure
- 131. Sealing means
- 132. Outgassing means
- 133. Connection fixing means
- 1331. Grommet
- 1332. Comb-like structure
- 134. Lid
- 2. Antenna module
- 21. Dielectric substrate
- 22. Antenna
- 221. Satellite antenna
- 222. Wi-Fi antenna
- 223. V2X antenna
- 224. 5G antenna
- V. Vehicle
- G. Glue path
- C. Cable

Detailed Description of the Invention

[0036] The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto but only by the claims.

5 **[0037]** While some embodiments described herein include some but not other features included in other embodiments, combinations of features of different embodiments are meant to be within the scope of the invention, and form different embodiments, as would be understood by those in the art. For example, in the following claims, any of the claimed embodiments can be used in any combination.

10 **[0038]** As used herein, spatial or directional terms, such as "inner", "outer", "above", "below", "top", "bottom", and the like, relate to the invention as it is shown in the drawing figures. However, it is to be understood that the invention can assume various alternative orientations and, accordingly, such terms are not to be considered as limiting. Further, all numbers expressing dimensions, physical characteristics, processing parameters, quantities
15 of ingredients, reaction conditions, and the like, used in the specification and claims are to be understood as being modified in all instances by the term "about". Accordingly, unless indicated to the contrary, the numerical values set forth in the following specification and claims are approximations that can vary depending upon the desired properties sought to be obtained by the present invention.

20 **[0039]** Moreover, all ranges disclosed herein are to be understood to be inclusive of the beginning and ending range values and to encompass any and all subranges subsumed therein. For example, a stated range of "1 to 10" should be considered to include any and all subranges between (and inclusive of) the minimum value of 1 and the maximum value of 10; that is, all subranges beginning with a minimum value of 1 or more, e.g. 1 to 6.1, and ending with a
25 maximum value of 10 or less, e.g., 5.5 to 10. Further, as used herein, the terms "deposited over" or "provided over" mean deposited or provided on but not necessarily in surface contact with. For example, a coating "deposited over" a substrate does not preclude the presence of one or more other coating films of the same or different composition located between the deposited coating and the substrate.

30 **[0040]** Where the term "comprising" is used in the present description and claims, it does not exclude other elements or steps. Where an indefinite or definite article is used when referring to a singular noun e.g. "a" or "an", "the", this includes a plural of that noun unless something

else is specifically stated. In this document, "configured to (or set to)" may be interchangeably used in hardware and software with, for example, "appropriate to", "having a capability to", "changed to", "made to", "capable of", or "designed to" according to a situation. In any situation, an expression "device configured to do" may mean that the device "can do" together with another device or component.

[0041] Furthermore, the terms first, second and the like in the description and in the claims, are used for distinguishing between similar elements and not necessarily for describing a sequence, either temporally, spatially, in ranking or in any other manner. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described or illustrated herein. When it is described that a constituent element (e.g., a first constituent element) is "(functionally or communicatively) coupled to" or is "connected to" another constituent element (e.g., a second constituent element), it should be understood that the constituent element may be directly connected to the another constituent element or may be connected to the another constituent element through another constituent element (e.g., a third constituent element).

[0042] In the following description, unless otherwise specified, expression "substantially" or "around" or "proximity" or "close to" preferably mean to within 10%, preferably to within 5% i.e., in this context the terms should be understood as in the range of $\pm 10\%$, even more $\pm 5\%$.

Tolerance may be selected depending on the nature of the intended applications.

[0043] Throughout the text, unless otherwise specified, expression "spoiler assembly" and "assembly" and "spoiler" are used interchangeably, and also the expression "module" and "antenna module" are used interchangeably, and also the expression "cover part" and "outer surface of spoiler assembly" and "the upper surface of the spoiler assembly" are used interchangeably, and also the expression "dielectric substrate" and "printed circuit board" are used interchangeably, and also the expression "antenna" and "antenna element" are used interchangeably, and also the expression "area" and "zone" are used interchangeably.

[0044] The vehicle in Figure 1 is a motor vehicle that includes a rear spoiler mounted at the rear of the vehicle and extending from the trunk of the vehicle to provide an aerodynamic surface substantially aligned with the trunk of the vehicle to provide a continuous surface. Although, a motor car is shown, the invention is applicable to other types of motorized vehicle

that utilize a spoiler assembly (1). In a preferred embodiment of the present invention, the spoiler assembly (1) is the rear spoiler of an automobile.

[0045] According to the Figure 3, an antenna module (2) are located within the rear spoiler. The antenna module (2) includes two or more antennas (22) distributed laterally on a dielectric substrate (21) as shown in Figure 2.

[0046] The present invention provides a spoiler assembly (1) for a vehicle (V) provided on the exterior of the vehicle, preferably on the rear side of the vehicle, comprising a cover part (12) having an outer surface facing outside world and a lower part (11) configured to be attached on the exterior side of the vehicle (V) and an antenna module (2) comprising a plurality of antennas (22); wherein the plurality of antennas (22) are formed on a dielectric substrate (21), and the antenna module (2) is situated between the cover part (12) and the lower part (11); wherein the assembly/joining of the cover part (12) and the lower part (11) configured to provide an enclosure (13) for the antenna module (2).

[0047] A spoiler assembly (1) of a vehicle (V) is mainly used for improving aesthetics or the aerodynamics performance of the vehicle, the shape/structure of the spoiler assembly (1) depends on many constraints like the vehicle body and so on. Therefore, the spoiler assembly (1) is not necessarily limited to the rear side of the vehicle, it may also extend over the roof of the vehicle or the sides of the vehicle. Moreover, the spoiler assembly (1) may comprise many parts to provide the desired effects, essentially it comprises two main parts which are the cover part (12) and the lower part (11), in the same logic, the lower (11) or the cover part (12) may comprise sub-parts.

[0048] The cover part (12) may be part of the spoiler (1) of the vehicle, especially the cover part (12) is the upper surface of the spoiler assembly (1) used for the aesthetic and/or aerodynamic purposes, such as the shell of the spoiler (1). In other words, the cover part (12) may be uppermost part of the spoiler (1), the thickness of those cover parts (12) differs depending on the requirements, however typically ranging from 1 mm to 5 mm, and the cover part (12) is usually a flat surface having a contour. Such parts of the vehicles (V) are produced in general from plastic/polymeric or alike materials so that allowing radio signals to be transmitted or received, i.e., transparent in terms of RF signal transmission. Behind the cover part (12), a lower part (11) is provided, the lower part (11) is fixed/mounted to the vehicle body/chassis, the said fixation may accomplished by clipping, screwing or any other fixation method known and the lower part (11) may comprise sub-parts for better functioning of the

said feature. The lower part (11) is usually used as a base for the cover part (12), i.e., the cover part (12) is mounted/supported over the lower part (11).

[0049] The assembly of the cover part (12) over the lower part (11) may be realized by welding, gluing, clipping or any efficient method known, the common practice is to glue the two parts (11, 12) together. In the gluing process, the lower part (11) may comprise a glue path (G) constructed by at least one rib (111) provided on the lower part (11). The glue is applied as beads or as lines onto the glue path (G), and then the cover part (12) is placed over the lower part (11) for permanent fixation. Instead of glues, different adhesives may also be used, one another common practice is to apply double sided adhesive tape over the glue path (G), i.e., assembly is not limited to glue. The glue path (G) may constructed in many ways, the glue may be applied over the rib (111) and the two parts joined together, or the glue may be applied in between two adjacent ribs (111) and the two parts joined together. The glue path (G) usually lies around the periphery of the inner sides of the cover/lower part (11, 12) to ensure the fixation of the cover part (12) onto the lower part (11), depending on the structure of the lower part (11) and the cover part (12), it may also cover other areas on the both parts (11, 12). On top of the gluing process, additionally clipping or welding of the two parts (11, 12) may also be applied in order to improve the strength of the fixation. In the assembled spoiler (1), there is free space or gaps inbetween the lower part (11) and the cover part (12) or in the lower part (11) itself due to its mechanical structure.

[0050] In a preferred embodiment, the antenna module (2) is mounted over the lower part (11), and then the cover part (12) joins with the lower part (11) to provide the enclosure (13) for the antenna module (2). Furthermore, in another preferred embodiment, the whole spoiler assembly (1) with the antenna module (2), could be joined separately and then mounted to the vehicle (V). The enclosure (13) of the present invention is large enough to accommodate the antenna module (2), preferably the enclosure (13) has dimensions of at least 100 mm x 50 mm x 5 mm (length x width x height). The enclosure (13) should be understood as the free space/volume enclosed by the lower part (11) and the cover part (12), i.e., created by the assembly of the lower part (11) and the cover part (12), in other words, the top side of the enclosure (13) is comprised of the inner side of the cover part (12) and the bottom side of the enclosure is comprised of the inner side of the lower part (11). The directions/positions should be understood from top to bottom as the outer surface of the

cover part (12), the inner surface of the cover part (12), free available space, the inner surface of the lower part (11), the bottom surface of the lower part (11) and the vehicle body/chassis.

[0051]In one embodiment, the lateral sides of the enclosure (13) are comprised of the lower part (11), i.e., the enclosure (13) is mainly made of by the lower part (11). As mentioned above, the lower part (11) in most cases has free space available to accommodate an article, in this embodiment, the enclosure (13) is made mainly from the lower part (11) except the top side of the enclosure (13) like a box with open top. Thus the antenna module (2) is housed in the available space in the lower part (11) and the assembly of the spoiler (1) ensures the closure of the enclosure (13), i.e., the installation of the antenna module (2) requires no additional production steps, which ensures significant cost/time reductions compared to the state of the art integration techniques for the antenna modules (2) for spoilers (1).

[0052]In another embodiment, a glue path (G) is constructed along the periphery of the enclosure (13). The glue path (G) around the periphery of the enclosure is structurally same with the glue path for the spoiler assembly process described above. Periphery of the enclosure (13) should be understood as the area of the contour of the lower part (11) where the antenna module (2) located. Application of glue over the glue path (G) of the enclosure (13) enables protection of dust or other environmental effects of the enclosure (13) in addition improving the strength of fixation of lower part (11) and the cover part (12). In a version of this embodiment, at least one rib (111) provided on the lower part (11) alongside the periphery of the enclosure (13) for constructing the glue path (G), i.e., the ribs (111) are guiding the glue path (G). The glue path (G) should be understood as an imaginary contour where the glue or the adhesives are applied. Height of such ribs (111) for the glue path are commonly in the range of 0.1 mm to 5 mm.

[0053]According to one another embodiment, each of the cover part (12) and the lower part (11) comprise ribs on their joining sides, i.e., on their inner sides, the said ribs configured to be aligned with each other to provide the enclosure (13), this embodiment is not illustrated in the figures. Both of the cover part (12) and the lower part (11) preferably comprise ribs on their inner sides that the ribs are substantially perpendicular to the outer surface of said components to provide the structural integrity of the spoiler (1). Such ribs in the present invention are aligned with corresponding counter rib on the other part to provide the enclosure (13) for the antenna module (2), the side walls of the enclosure (13) in this case should be understood as the walls of the ribs of the lower part (11) and the cover part (12).

[0054] In different embodiments, a sealing means (131) is applied over the glue path (G). The sealing means (131) can be the same adhesive material used for the assembly of the lower part (11) and the cover part (12), i.e., the glue in the gluing process as described above. Depending on the intended sealing level of the enclosure (13), different materials than the adhesives applied in the assembly process of the spoiler (1) may be used, for example the sealing means (131) may be the sealing achieved around the enclosure (13) by the vibration/ultrasonic welding used in the assembly process. The sealing means (131), in a version of this embodiment, provides watertightness for the enclosure (13) to protect the antenna module (2) from water. Providing a water-proof enclosure (13) allows the antennas (22) work seamlessly without affected by environmental conditions, i.e., allows a long lasting operation. Here forth, the water-proofness of the enclosure (13) should also be understood as the water-proofness of the antenna module (2).

[0055] In another embodiments, the enclosure (13) comprises an outgassing means (132) for outgassing of the gas inside the enclosure (13), i.e., the outgassing means (132) provides venting for the enclosure (13). Although the enclosure (13) is provided to be watertight, there is always the probability of condensation because of the temperature changes. And said condensation probability may damage the antenna module (2) and vacuuming the enclosure (13) is not feasible and cost-efficient. In addition to the water vapor condensation issue, it is important to maintain/manage a pressure balance between the inside and outside of the enclosure (13) due to thermal expansion. The enclosure (13) may comprise a hole or alike on its surroundings and the outgassing means (132) is configured to close the hole in a watertight manner and allowing outgassing of gas like the water vapor like a membrane. In a version of this embodiment, the outgassing means (132) may be the sealing means (131) itself, i.e., the sealing means (131) has such a porous structure that it allows gas to pass and not allowing liquid to pass to provide both watertightness and outgassing of the water vapor/gas/air. The outgassing means (132), in another version of the embodiment, is an one-way membrane that it only allows the gas inside the enclosure (13) to get out and does not allow air to go into the enclosure (13).

[0056] In different embodiments, the sealing means (131) and/or the outgassing means (132) is/are made from polytetrafluoroethylene (PTFE) material. The material of the sealing means (131) or the outgassing means (132) is not limited to as such and may be chosen differently depending on the function needs to be realized by such element.

[0057]In another embodiment of the present invention, the enclosure (13) comprises a connection fixing means (133) allowing the electronic connection (C) from the antenna module (2) to be connected to the vehicle in a watertight manner. The antenna module (2) inside the spoiler assembly (1) needs to be connected to the electronics inside the vehicle, i.e., telematics control unit (TCU) or alike through transmission lines, i.e., by cabling. The connection fixing means (133) should be understood as the means for enabling the cables (C) coming out from the antenna module (2) to reach outside of the enclosure (13), to this end, it may be a simple hole on the enclosure (13) for cables (C) to come out. The connection fixing means (133) is preferably a flexible element on the enclosure (13) allowing the cables (C) going out from the enclosure (13) in a watertight manner. The connection fixing means (133) may provide the watertightness per se or the water-proofness may be granted to the connection fixing means (133) with additional processes like filling/potting with a resin/silicone afterwards the cables (C) passed-through the connection fixing means (133). Below two different embodiments for the connection fixing means (133) are described in detail.

[0058]In another embodiment of the present invention, the connection fixing means (133) is a grommet (1331) provided on the enclosure (13). The cables (C) from the antenna module (2) passed through the grommet (1331) and then are connected to the electronics of the vehicle (V). The enclosure (13) in this embodiment does not necessarily be like a box-shape, the grommet (1331) may be provided like an extension to the enclosure (13) that the cables (C) from the antenna module (2) lie down inside the enclosure (13) before going into the grommet (1331). The grommet (1331) may provide the waterproofness per se or as described above it may be turned into waterproof state by additional steps.

[0059]In another embodiment of the present invention, the connection fixing means (133) is made of two opposite-facing comb-like structure (1332). Similar to above embodiment, the connection fixing means (133) may be like an extension to the enclosure (13). The comb-like structure (1332) has at least number of teeth equal the number of cables (C) coming out from the antenna module (2). Each cable (C) from the antenna module (2) is directed over the comb-like structure (1332) and directed to the electronics of the vehicle (V).

[0060]In another embodiment of the present invention, the antenna module (2) is accessible from outside without disarranging the spoiler assembly (1). As described above, the lower part (11) and the cover part (12) are joined together in a permanent way by the welding or

gluing process, i.e., it is usually not possible to separate the lower part (11) and the cover part (12) without breaking although this is not the case for all spoilers. In the preferred version of this embodiment, the antenna module (2) is accessible from the bottom side of the lower part (11), i.e., the access to the antenna module (2) is provided after the spoiler assembly (1) is demounted from the vehicle. By this embodiment, the antenna module (2) is enabled to be serviced or replaced or updated in the case of need. Moreover, the spoiler assembly (1) is provided to be recycled efficiently with the help of easy removal of the antenna module (2) from the spoiler assembly (1). In another version of this embodiment, the antenna module (2) may be accessed without removing the spoiler (1) from the vehicle (V).

[0061] In a version of this embodiment, the enclosure (13) comprises an openable lid (134) provided on the bottom part of the lower part (11). The lid (134) may be the base of the enclosure (13) where the antenna module (2) placed. The antenna module (2) can be accessed through the lid (134). In different versions, the sealing means (131) is also provided around the lid (134) to seal the enclosure (13). The sealing means (131) around the lid (134) may have the same functions as the sealing means (131) described above.

[0062] The antenna module (2) comprising a dielectric substrate (21), and the plurality of antennas (22) deployed on the dielectric substrate (21) as described in Fig. 2. In some embodiments, the antenna module (2) is manufactured as a pre-fabricated module that it can directly be installed into the spoiler assembly (1), i.e., into the enclosure (13). The size of the antenna module (2) is arranged to be fitted into the enclosure (13) behind the cover part (12), i.e., the free/available volume in the lower part (11). More precisely, the antenna module (2) enjoys a predefined maximum size (length x width x height) of around 250 mm x 75 mm x 20 mm. In a preferred embodiment, the size of the antenna module (2) is smaller than the predefined maximum size, more preferably less than 220 mm X 60 mm X 15 mm, even more preferably less than 200 mm X 50 mm x 10 mm. It is clear that the size of the antenna module (2) depends on number of antennas (22) deployed on the dielectric substrate (21), the example sizes given above are for an antenna module (2) with 4 – 6 antennas (22) deployed, for an antenna module (2) with 2 – 3 antennas (22), the size of the antenna module (2) is much smaller than the values herein, for example 100 mm X 40 mm X 5 mm. Preferably, the antenna module (2) is snap-fitted into the enclosure (13). Thanks to the enclosure (13) provided inside the spoiler (1), the antenna module (2) does not need a housing or a cover or alike to protect the antennas (22), i.e., the antenna module (2) may be the bare naked

dielectric substrate (21) and antennas (22) deployed on the former (21), such formation allows the distance in between the antennas (22) to be broadened, meaning better antenna performance in the same enclosure (13) volume. Depending on the requirements and constraints, the antenna module (2) may have a cover/housing over the dielectric substrate (21).

[0063] The antennas (22) in the antenna module (2) of the present invention can be various combinations of 2G, 3G, 4G, 5G, Wi-Fi, V2X, UWB and satellite antennas, providing that at least two antennas (22) formed on the dielectric substrate (21) and in a different embodiment, there are at least two different operating frequencies. On account of at least two antennas (22) and at least two different frequencies should be understood that in the case of only two antennas (22), the two antennas (22) work in different frequencies, and in the case of more than two antennas (22) situated on the dielectric substrate (21), then at least two antennas (22) among the plurality of antennas (22) may work in the same frequency. In general, the antennas (22) provided on the dielectric substrate (21) may operate in the same frequency range or in different frequency ranges. The frequency should also be understood as the frequency range or frequency band. In different embodiments, the said antennas (22) working at least two different range of frequencies.

[0064] According to one embodiment of the present invention, the dielectric substrate (21) has five zones, zone 1 is the center area of the dielectric substrate (21), i.e., in the middle of the dielectric substrate (21), zone 4 and zone 5 are the extreme sides of the dielectric substrate (21) respectively, i.e., the dielectric substrate (21) has an elongated shape and zone 4 and 5 are located on the lateral/extreme edges, zone 2 is in between zone 1 and zone 4, zone 3 is in between zone 1 and zone 5. Therefore, looking from above, the zones left to right are zone 5, zone 3, zone 1, zone 2, zone 4. The zones are not necessarily divided as areas with same size, however zone 3 always stays in the middle of the dielectric substrate (21), therefore the borders of side zones (zone 1, 2, 4 and 5) are subject to change in order to arrange the size of the said zones.

[0065] In a preferable embodiment of the present invention, a satellite antenna (221) is located in the zone 1, two 5G antennas (224) deployed on the dielectric substrate (21) and one located in zone 5 and the other in zone 4, a Wi-Fi antenna (222) located in zone 3 and a V2X antenna (223) located in zone 2. Depending of the viewing perspective, the Wi-Fi antenna (222) can be in zone 2 and the V2X antenna (223) can be in zone 3. Thus a maximum of two

antennas (22) operating in the same/similar frequency are preferred on the dielectric substrate (21) to both eliminate signal attenuation or strong coupling between antennas (22) and reduce the size of the antenna module (2). Thus, according to preferred embodiment of the present invention, the dielectric substrate (21) may be divided in at least five zones:

- Zone 1 where the satellite antennas (221) are provided,
- at least one lateral area (zone 4 and/or zone 5) at the left and/or the right extremities of the dielectric substrate (21), where the cellular antennas (224) and/telematic antennas (224) are provided;
- a further area (zone 2 and/or zone 3) provided between the central area and the lateral area where V2X and/or Wifi antennas (222, 223) are provided.

Further, the signal to noise ratio of the antennas (22) may be improved according to one embodiment as a particular arrangement of the present invention.

[0066] In general, the dielectric substrate (21) may be rigid or flexible. The dielectric substrate (21) might be a regular printed circuit board (e.g., a fiberglass-filled epoxy board such as an FR4 board), or being formed by epoxy resin, flexible print circuit, plastic-substrates, the substrate being formed by other suitable dielectrics or other suitable substrates of having filled glass fiber, or may be formed from rigid printed circuit board materials such as fiberglass-filled epoxy, flexible printed circuits (e.g., printed circuits formed from flexible sheets of polymer such as polyimide), or rigid flex circuits (e.g., printed circuits that contain both rigid portions and flexible tails), or may be formed of a flexible polymer sheet, such as a polyimide sheet or other flexible dielectrics or from PET (Polyethylene terephthalate), or from PI (polyimide resin), or from PEN (Polyethylene naphthalate) or other suitable substrate material or other dielectric substrate. A flexible printed circuit board may be formed of a flexible polymer sheet, such as a polyimide sheet or other flexible dielectrics. The antennas (22) may be printed over the dielectric substrate (21) or fixed/attached over it in other ways known in the art, in a preferred embodiment, the antennas (22) are provided planarly over the dielectric substrate (21).

[0067] In another embodiments, the antenna module (2) may be placed vertically or horizontally with referenced to the ground, inside the enclosure (13). For example, the module (2) may be placed vertically or horizontally into the enclosure (13). In different versions of this embodiment, the module (2) may be placed vertically into the spoiler (1) depending on the nature of the intended applications. Indeed, the antenna module (2) can

be placed in any orientation with respect to the ground inside the spoiler (1) provided better coverage and better performance for the application.

[0068] The integration process can be summarized as follows; a free volume is available in the lower part (11) of the spoiler (1) to accommodate an article, the antenna module (2) is placed over the said volume and the said volume is enclosed by the assembly of the lower (11) and cover part (12) of the spoiler (1). A sealing means (131) is applied over the periphery of the said enclosure (13), and the sealing means (131) may enable the enclosure (13) to be waterproof. The transmission lines/cables (C) of the antenna module (2) are connected to the electronics of the vehicle by the connection fixing means (133).

[0069] With the present invention, the integration of an antenna module (2) having multiple antennas (22) into the spoiler (1) of a vehicle (V) is realized without leading or requiring additional steps in the manufacturing process, apart from the advantages of having antennas inside the spoiler listed in the introduction. As described above in detail, the antenna module (2) is integrated into the spoiler (1) seamlessly in the conventional assembly process, providing added value with practically no expenditure. Moreover, thanks to provided waterproof enclosure (13), the antenna module (2) is protected from environmental effects, increasing the longevity of the product. Lastly but not least, thanks to the enclosure (13) already provided in the spoiler (1) itself protecting the antenna module (2) from the environmental effects, the antenna module (2) may be without a cover or a housing, meaning ability to improve antenna performance in the same volume or add more antennas (22) into same volume.

[0070] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. The foregoing description details certain embodiments of the invention. It will be appreciated, however, that no matter how detailed the foregoing appears in text, the invention may be practiced in many ways. The invention is not limited to the disclosed embodiments.

CLAIMS

1. A spoiler assembly (1) for a vehicle, said spoiler assembly (1) comprising:
 - a. at least one cover part (12) having an outer surface facing outside world and at least one lower part (11) configured to be fixed on the vehicle;
 - 5 b. at least one antenna module (2) having plurality of antennas (22); wherein the plurality of antennas (22) are deployed on a dielectric substrate (21);
 - c. the antenna module (2) is situated between the cover part (12) and the lower part (11);wherein the assembly of the cover part (12) and the lower part (11) configured to provide
10 an enclosure (13) for the antenna module (2),
and wherein the enclosure (13) enables the antenna module (2) to be accessed without disengaging the lower part (11) and the cover part (12).
2. A spoiler assembly (1) according to claim 1, wherein the antenna module (2) is provided on the lower part (11).
- 15 3. A spoiler assembly (1) according to claim 1 or 2, wherein a sealing means (131) is provided all around the periphery of the enclosure (13).
4. A spoiler assembly (1) according to claim 3, wherein the sealing means (131) provides the enclosure (13) to be water-proof.
5. A spoiler assembly (1) according to anyone of preceding claims, wherein the enclosure
20 (13) comprises an outgassing means (132) for outgassing/venting of the gas inside the enclosure (13).
6. A spoiler assembly (1) according to anyone of preceding claims, wherein the enclosure (13) comprises a connection fixing means (133) allowing the transmission lines from the antenna module (2) to be connected to the vehicle in a watertight manner.
- 25 7. A spoiler assembly (1) according to claim 1, wherein the enclosure (13) comprises an openable lid (134) provided on the bottom part of the lower part (11).
8. A spoiler assembly (1) according to anyone of preceding claims, wherein the antennas (22) provided planarly on the dielectric substrate (21).
9. A spoiler assembly (1) according to anyone of preceding claims, wherein the antennas
30 (22) are operating at least two different range of frequencies.
10. A spoiler assembly (1) according to anyone of preceding claims, wherein the antennas (22) are at least one of 2G, 3G, 4G, LTE, 5G, Wi-Fi, UWB, satellite or V2X antenna.

11. A spoiler assembly (1) according to claim 10, wherein one satellite antenna (221) is placed in the central area of the dielectric substrate (21), wherein one 5G antenna (224) is placed in the each lateral side of the dielectric substrate (21) respectively, wherein one Wi-Fi antenna (222) and one V2X antenna (223) are placed in between central area and lateral sides of the dielectric substrate (21).
12. A vehicle comprising a spoiler assembly (1) according to claims 1 to 11.
13. A method of integration of an antenna module (2) comprising plurality of antennas (22) deployed on a dielectric substrate (21) into a spoiler assembly (1) comprising at least one lower part (11) and one cover part (12) wherein the lower part (11) having a free volume to accommodate an article, comprising steps of
- Providing the antenna module (2) into the lower part (11),
 - Providing a sealing means (131) around the antenna module (2) onto the lower part (11),
 - Assembling of the lower part (11) and the cover part (12) of the spoiler to provide an enclosure (13) for the antenna module (2), wherein the enclosure (13) enables the antenna module (2) to be accessed without disengaging the lower part (11) and the cover part (12).

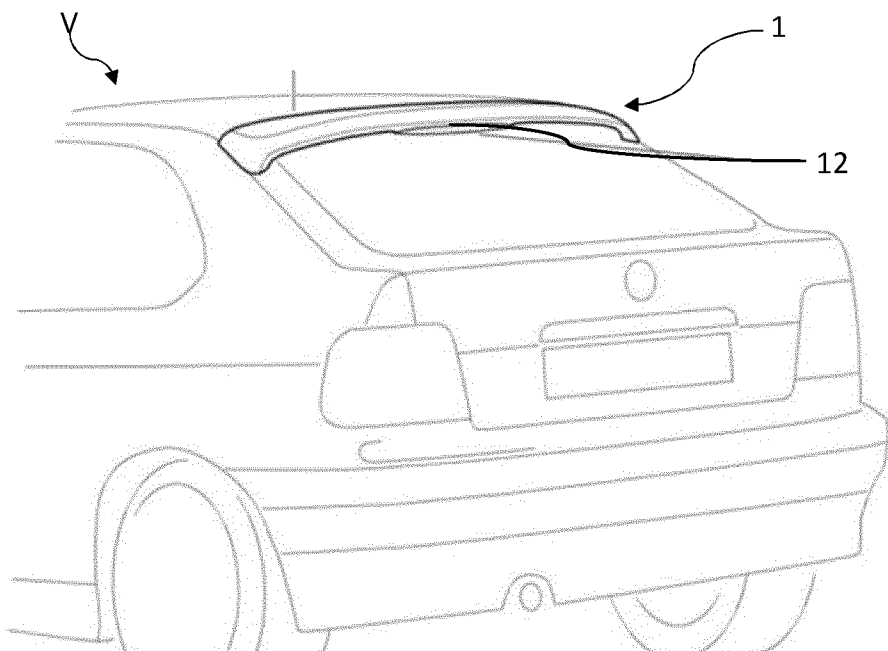


Fig.1

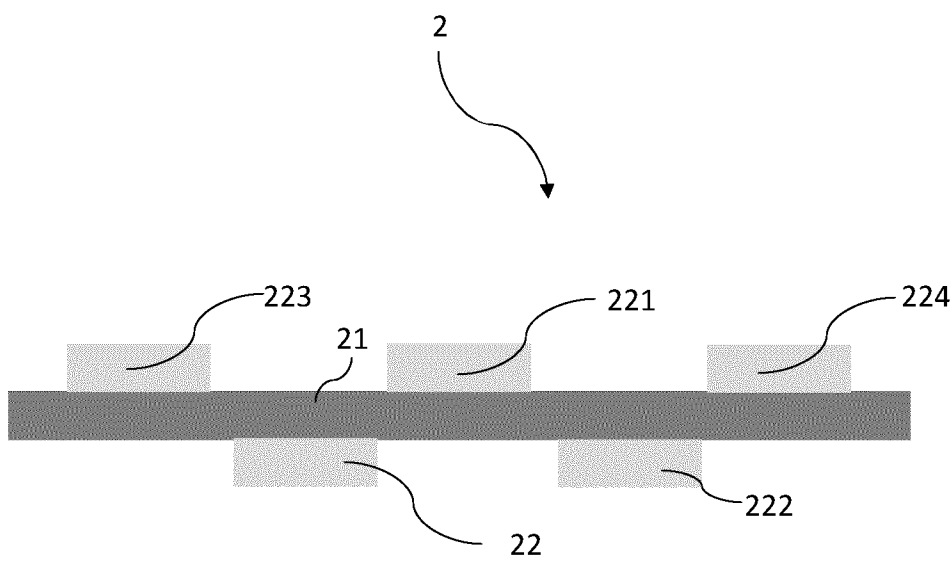


Fig.2

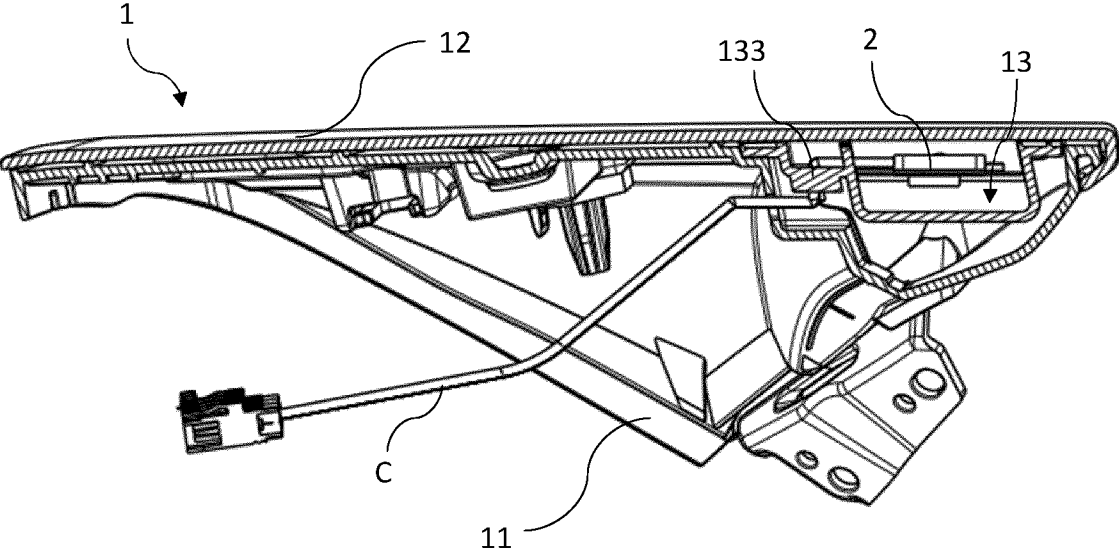


Fig.3

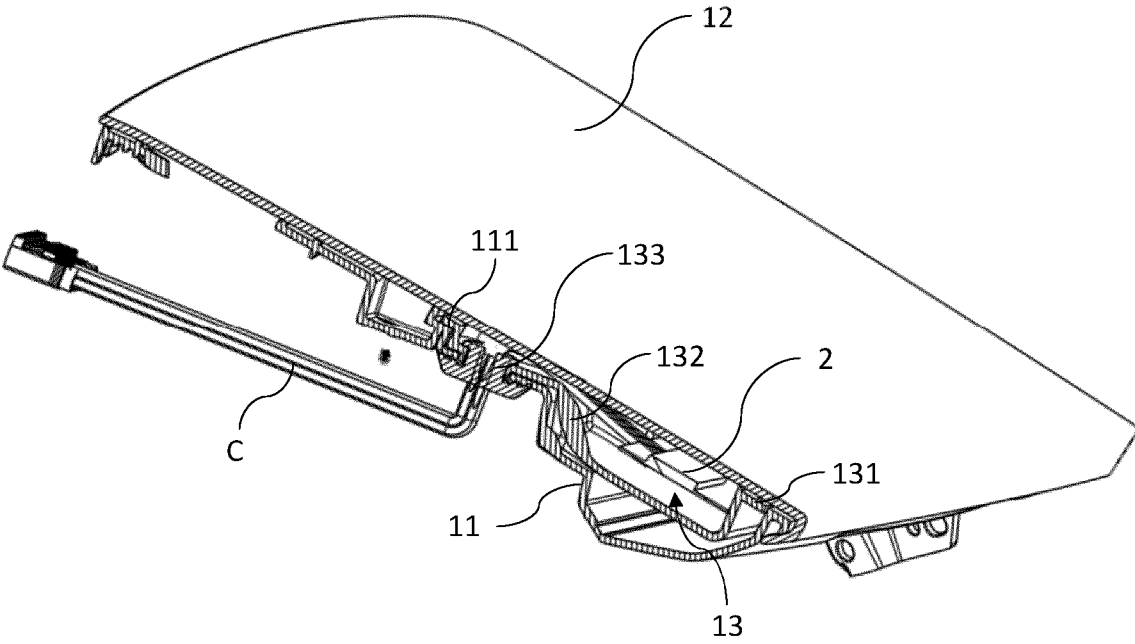


Fig.4

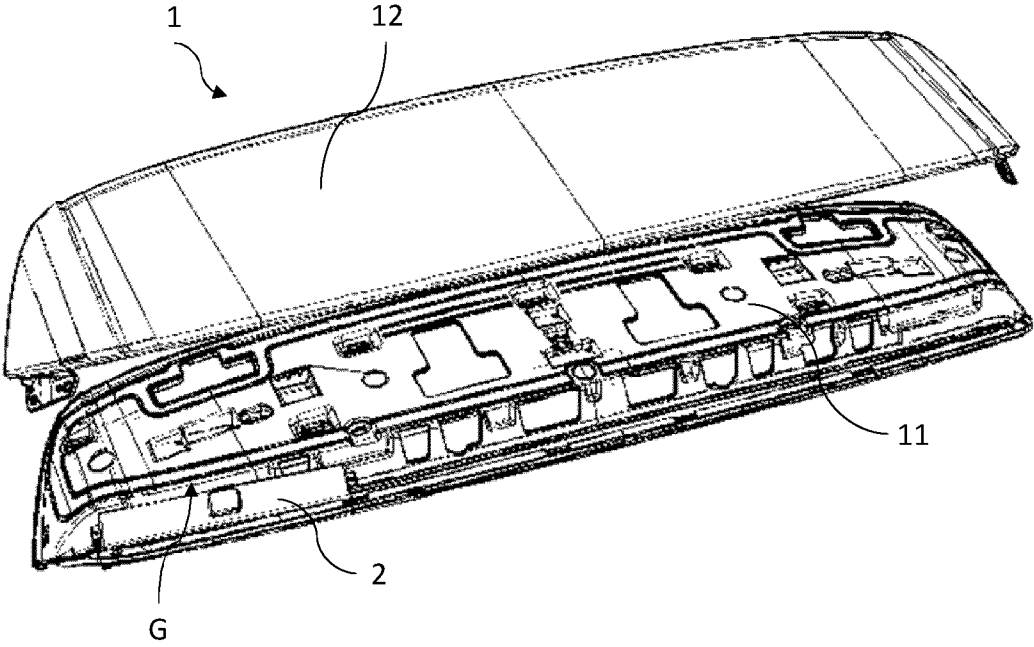


Fig.5

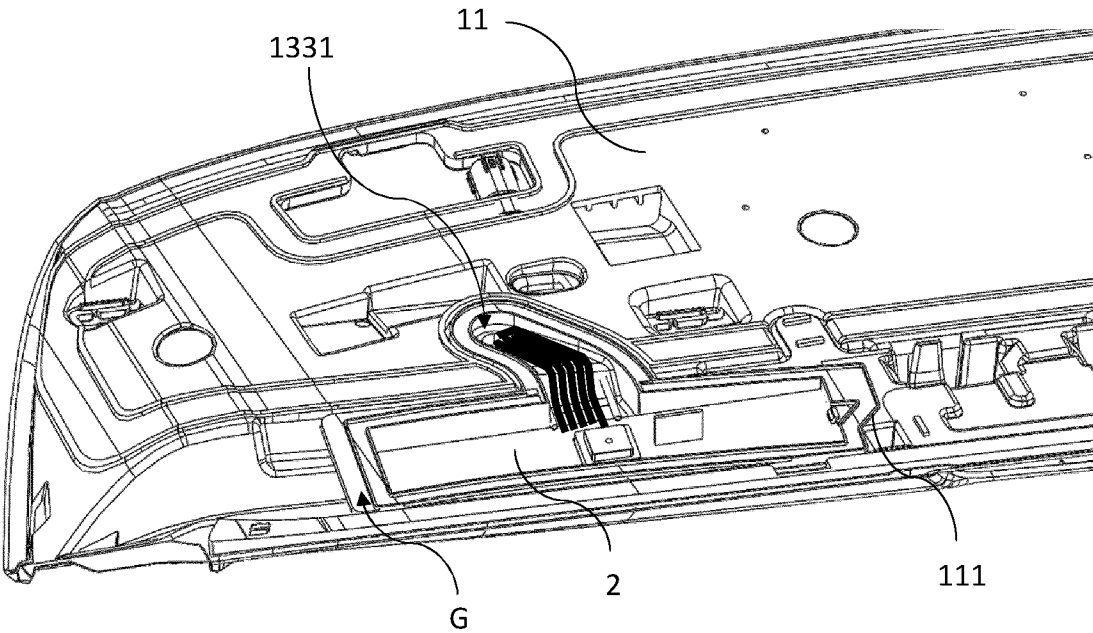


Fig.6

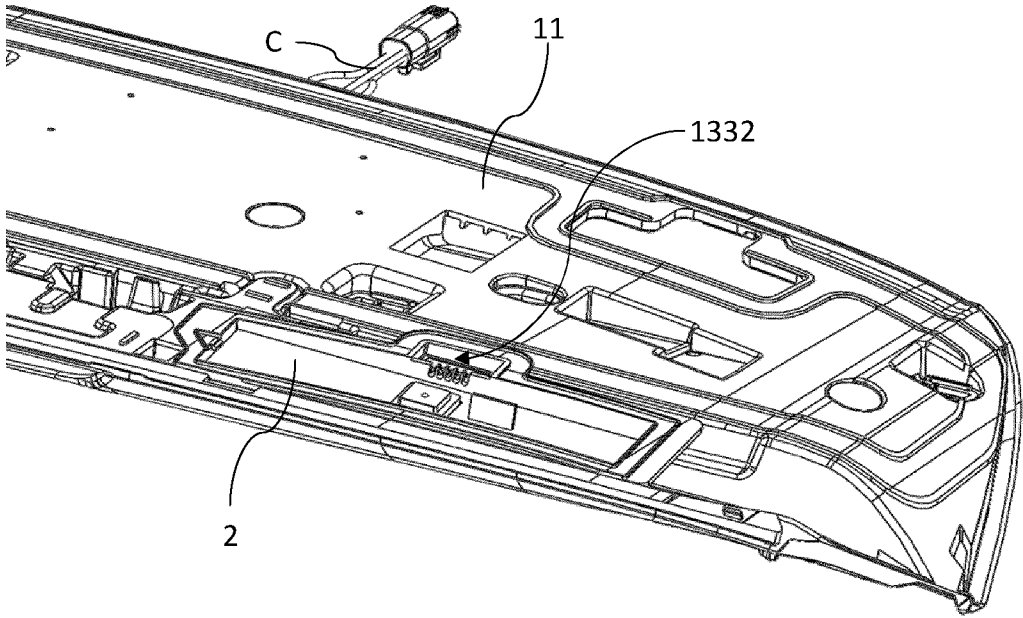


Fig.7

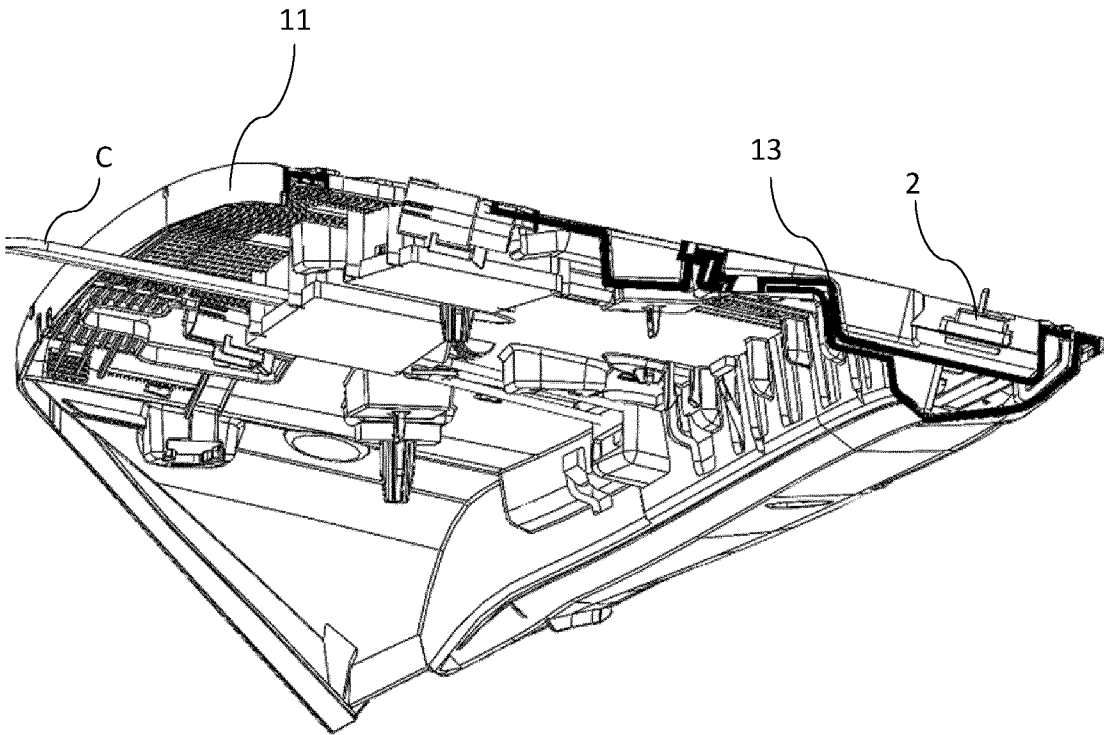


Fig.8

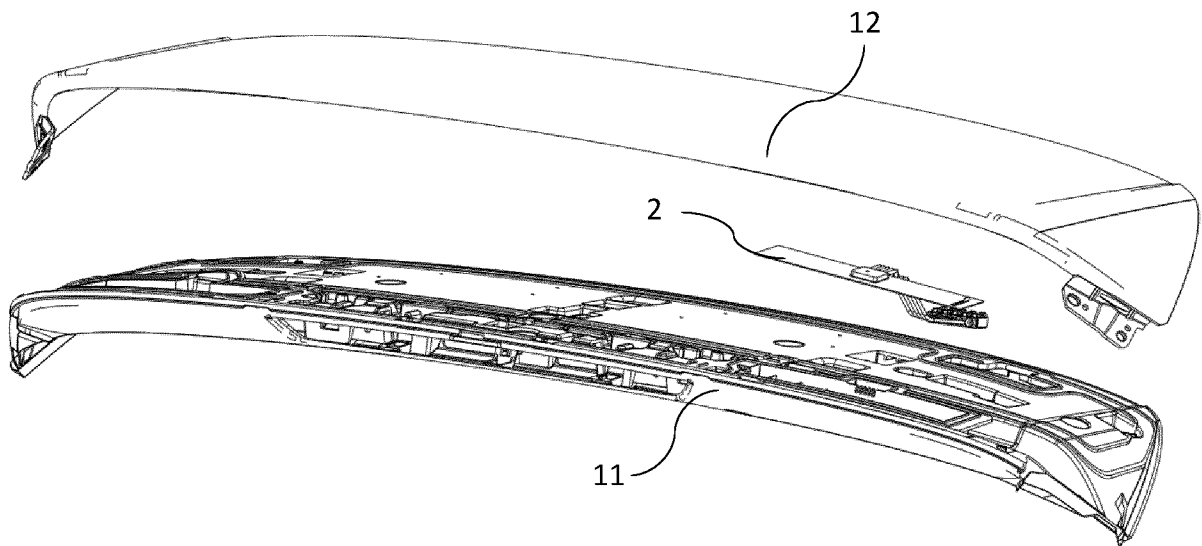


Fig.9

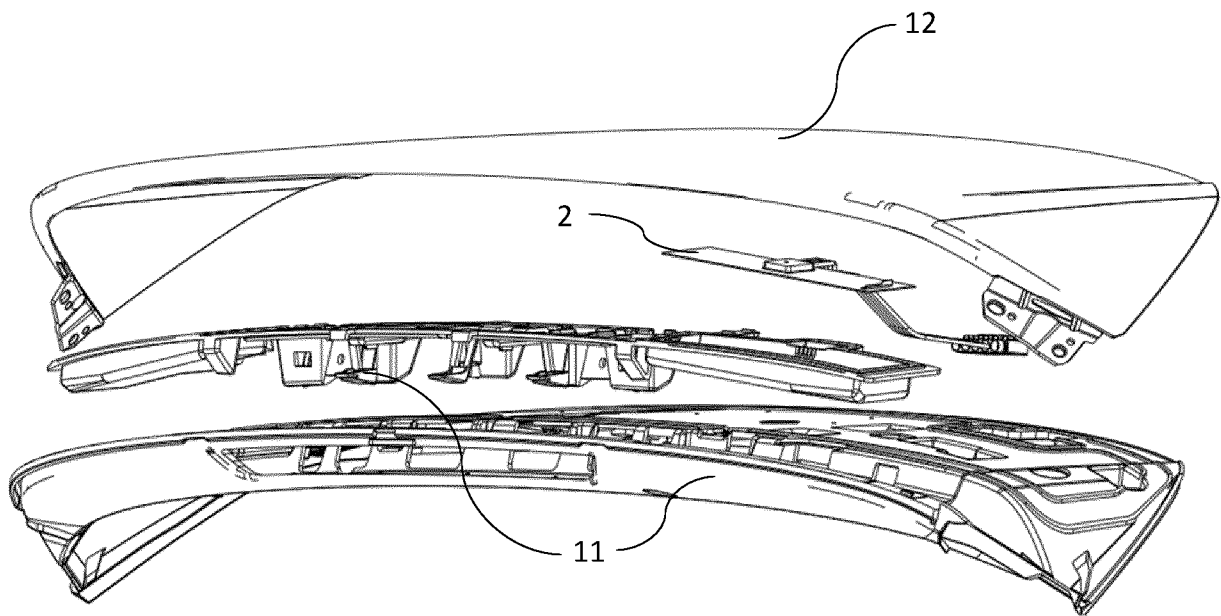


Fig.10

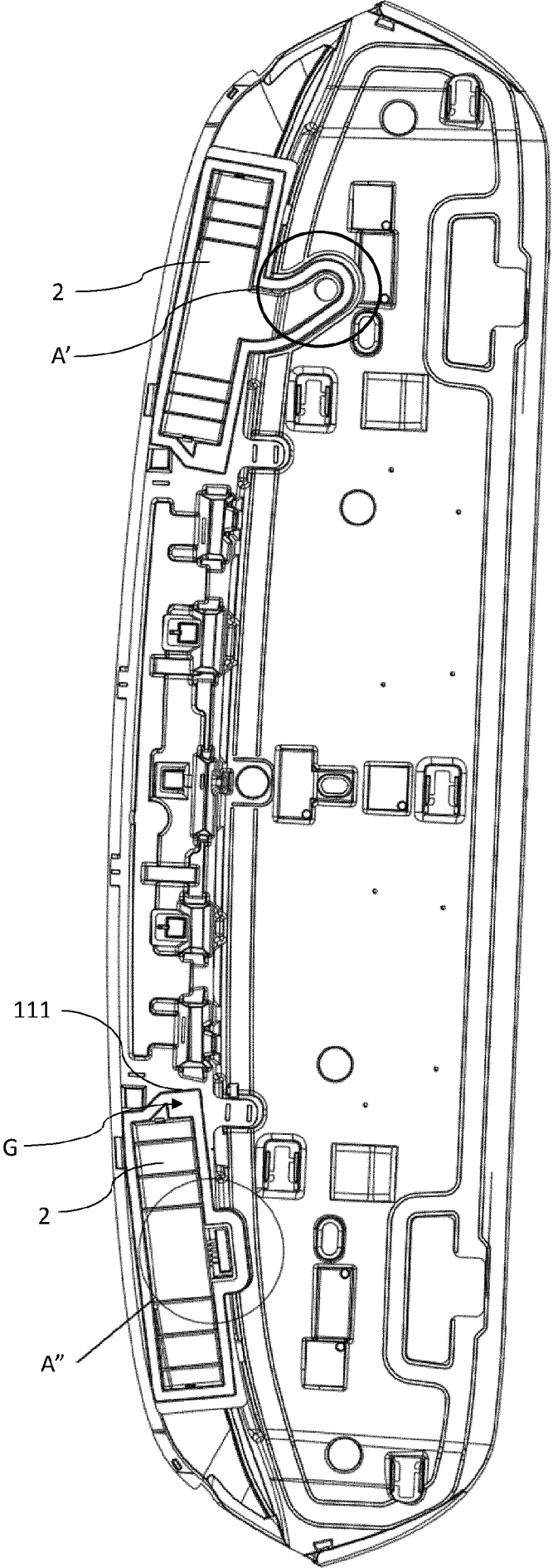


Fig.11

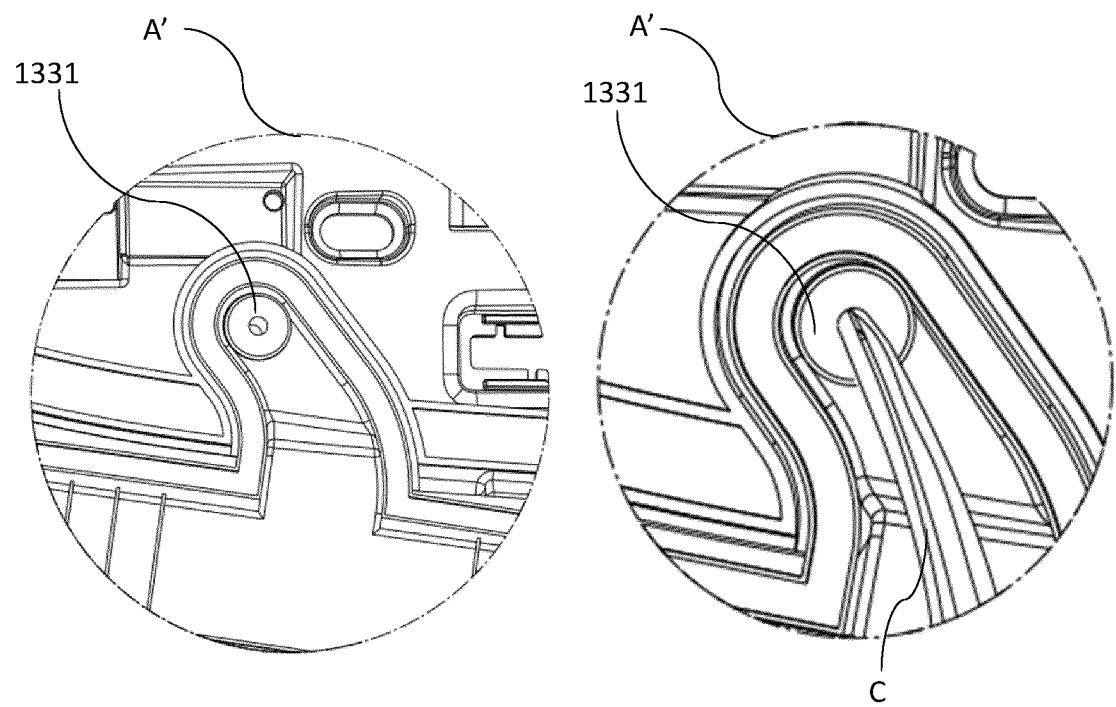


Fig.12

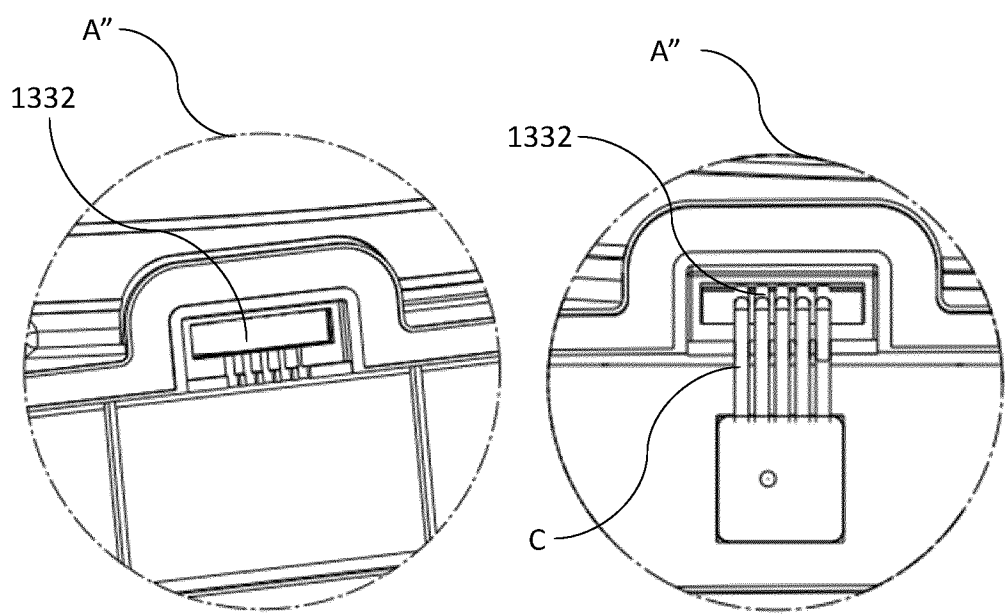


Fig.13

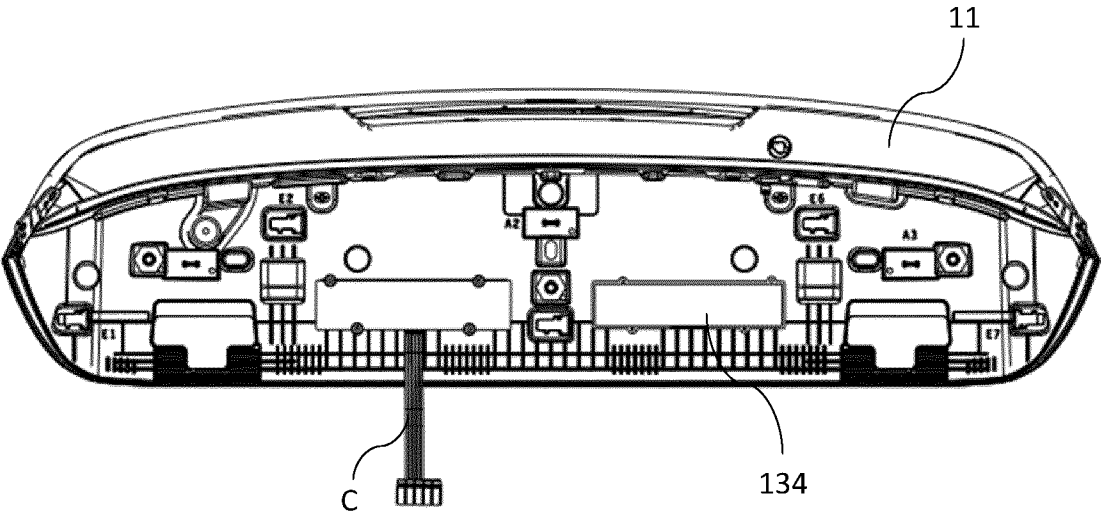


Fig.14

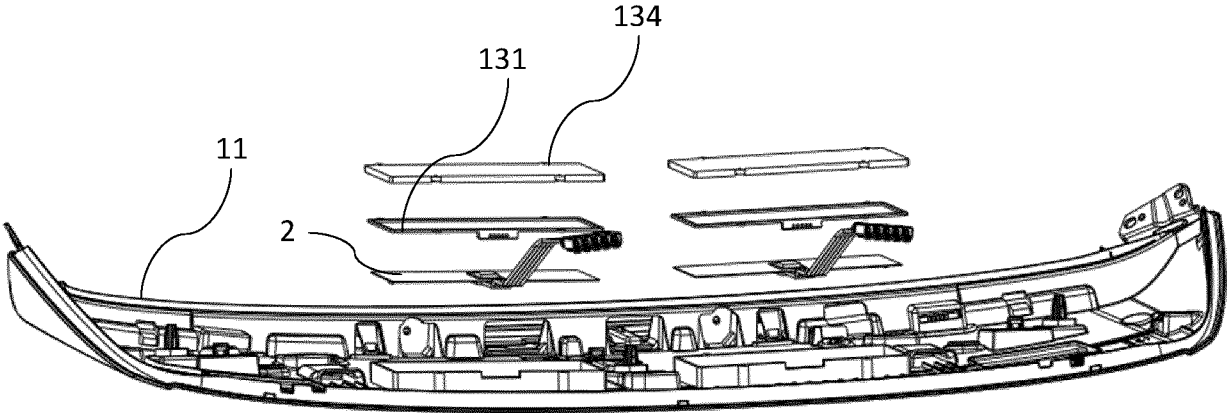


Fig.15

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2024/066439

A. CLASSIFICATION OF SUBJECT MATTER INV. H01Q1/32 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) H01Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance;; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance;; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 10 September 2024		Date of mailing of the international search report 19/09/2024
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Collado Garrido, Ana

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