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(54) ANTENNA AND ANTENNA ARRANGEMENT FOR A MOTOR VEHICLE, MOTOR VEHICLE AND METHOD FOR MANUFACTURING AN ANTENNA

(57) An antenna (4) for a motor vehicle (1) comprises a waveguide component (5) with a target region (8) for positioning a receiver and/or detector device (10). The waveguide component (5) comprises a plastic part (6) and an inner surface (7) of the plastic part (6) for guiding electromagnetic waves (11) from the target region (8) into an outer environment of the antenna (4) and/or from the outer environment to the target region (8) comprises a metal layer made of a galvanized or metallized metal.

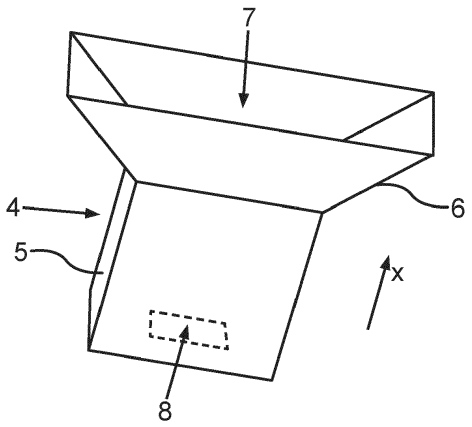

Fig.2

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Description

[0001] The present invention is directed to an antenna for a motor vehicle, the antenna comprising a waveguide component with a target region for positioning a receiver and/or transmitter device. The invention is further directed to an antenna arrangement for a motor vehicle comprising such an antenna, to a motor vehicle comprising such an antenna arrangement and to a method for manufacturing an antenna.

[0002] Antennas are used in motor vehicles for transmitting and/or receiving electromagnetic waves, for example for communication purposes or for environmental perception, for example by means of radar systems. Radar systems are used for various applications in motor vehicles, in particular for realizing driver assistance functions or other functions for guiding a vehicle automatically or in part automatically. Corresponding radar systems may, for example, comprise waveguide antennas, for example, slotted waveguide antennas or aperture antennas, such as horn antennas.

[0003] It is an objective of the present invention to provide an antenna for a motor vehicle, which has a waveguide component with high mechanical stability and low weight.

[0004] This objective is achieved by the respective subject-matter of the independent claims. Further implementations and preferred embodiments are subject-matter of the dependent claims.

[0005] The invention is based on the idea to use a waveguide component, which comprises a plastic part, whose inner surface for guiding electromagnetic waves is galvanized or metallized to form a metal layer.

[0006] According to an aspect of the invention, an antenna for a motor vehicle is provided. The antenna comprises a waveguide component and a target region for positioning a receiver and/or transmitter device. The waveguide component comprises a plastic part, and an inner surface of the plastic part comprises a galvanized metal layer or a metallized metal layer, which is a metal layer made by metallization.

[0007] The inner surface, which comprises the galvanized metal layer is for guiding electromagnetic waves from the target region into an outer environment of the antenna and/or from the outer environment to the target region.

[0008] In other words, the antenna is designed as a waveguide antenna, also denoted as waveguide fed antenna. The antenna may, for example, be designed as an aperture antenna or as a slotted waveguide antenna or as another antenna with a metal structure.

[0009] The antenna may be a communication antenna and/or a radar antenna, for example.

[0010] That the plastic part comprises the galvanized metal layer may be understood such that the plastic part is partially galvanized at its inner surface. In other words, the plastic part is a galvanized or partially galvanized plastic part. That the plastic part comprises the metallized metal layer may be understood such that the plastic part is partially metallized at its inner surface. In other words, the plastic part is a metallized or partially metallized plastic part.

[0011] In particular, the plastic part is designed to form an enclosure for guiding the electromagnetic waves, wherein the enclosure is open to the environment. The inner surface can be understood to face an interior of the enclosure.

[0012] The receiver and/or transmitter device may, for example, comprise a wave source for the electromagnetic waves, in particular for emitting the electromagnetic waves in a predefined frequency band, for example, in the range of several GHz or several tens of GHz, for example, between 10 GHz and 100 GHz or between 20 GHz and 85 GHz. The frequency band may be a frequency band as commonly used for automotive radar systems, for example, an automotive long range radar band, also denoted as LRR band, or an automotive short range radar band, also denoted as SRR band. The LRR band ranges from 76 GHz to 77 GHz, and the SRR band ranges from 77 GHz to 81 GHz, for example. Alternatively or in addition, the receiver and/or transmitter device may comprise electronic circuitry for detecting and/or processing the electromagnetic waves reaching the receiver and/or transmitter device from the environment of the antenna. The antenna can, however, be used with other frequencies as well.

[0013] Due to the metal layer, the waves can be guided properly from the target direction to the environment or vice versa. Since the electromagnetic waves penetrate the surface of the waveguide component only up to the respective penetration depth, which can, for example, be in the order of few micrometers or below one micrometer for the relevant frequency bands, there is no need for providing a waveguide component which is completely or predominantly made of metal. Rather, the plastic part, which provides sufficient mechanical stability of the waveguide component, may be made of various materials, for example by means of injection molding or extrusion, without significantly affecting the guidance of the electromagnetic waves. Consequently, providing the galvanized or metallized plastic part combines the beneficial electromagnetic properties for guiding the electromagnetic waves of the metal layer with low weight and high mechanical stability of the plastic material. In particular, also costs of the antenna may be reduced by using a galvanized or metallized metal layer instead of, for example, a solid metallic part as the waveguide component.

[0014] According to several implementations, the thickness of the metal layer is equal to or greater than a penetration depth of a material of the metal layer for a predefined frequency of the electromagnetic waves.

[0015] In this way, it is achieved that the guided electromagnetic waves are effectively decoupled from the plastic part, and the waveguiding properties are dominated vastly by the metal layer.

[0016] The thickness of the metal layer may, for exam-

ple, be less than 100 times the penetration depth or less than 50 times the penetration depth or less than 20 times the penetration depth or less than 10 times the penetration depth.

[0017] The smaller the thickness of the metal layer, the less is also the weight of the antenna and, for example, also the manufacturing costs of the antenna.

[0018] According to several implementations, the predefined frequency of the electromagnetic waves lies within the range of [10 GHz, 100 GHz].

[0019] Consequently, the most relevant frequency ranges for automotive applications are covered. For example, the frequency may lie within the range from 21 GHz to 26 GHz corresponding the so-called ultrawide band, UWB, range, within the range from 24 GHz to 24.25 GHz corresponding to the so-called narrow band ISM range, NB-ISM, within the range from 76 GHz to 77 GHz, which corresponds to the automotive LRR band or within the range from 77 GHz to 81 GHz, which corresponds to the automotive SRR band.

[0020] According to several implementations, the metal layer is made of silver or a silver alloy or is made of copper or a copper alloy.

[0021] Silver and copper as well as the corresponding alloys are well suitable materials for guiding the electromagnetic waves in the respective relevant frequency ranges. In particular, it is very beneficia to use a metal with a high electric conductivity. In particular, the higher the electric conductivity of the used metal, the thinner the metal layer can be made, in particular in view of the penetration depth.

[0022] According to several implementations, the antenna is an aperture antenna or a travelling wave antenna or a slotted waveguide antenna. According to several implementations, the antenna comprises the receiver and/or transmitter device, and the receiver and/or transmitter device is arranged and fastened to the target region.

[0023] According to a further aspect of the invention, an antenna arrangement for a motor vehicle is provided. The antenna arrangement comprises an antenna according to the invention and a body part for the motor vehicle. The antenna is fastened to the body part.

[0024] The antenna arrangement may for example be a communication antenna arrangement and/or a radar antenna arrangement. The antenna of the antenna arrangement is then designed as communication antenna and/or a radar antenna, accordingly.

[0025] According to several implementations of the antenna arrangement, the antenna is fastened to the body part by means of a clip connection.

[0026] To this end, the plastic part may, for example, comprise features, such as latching lugs, which engage with corresponding features of the body part in order to realize the clip connection. In this way, the antenna may be fastened to the body part securely in a particularly simple way.

[0027] According to several implementations of the antenna arrangement, the body part is a bumper for the motor vehicle or a grille for the motor vehicle.

[0028] According to a further aspect of the invention, a motor vehicle is provided. The motor vehicle comprises an antenna according to the invention or an antenna arrangement according to the invention.

[0029] According to a further aspect of the invention, a method for manufacturing an antenna according to the invention is provided. Therein, the waveguide component is provided, and the metal layer is generated by galvanizing or metallizing the inner surface of the plastic part.

[0030] In respective implementations, the receiver and/or transmitter device is provided and fastened to the target region.

[0031] According to several implementations of the method, the plastic part is produced by injection molding or by an extrusion process.

[0032] The invention also includes further embodiments of the method according to the invention which have features as already described in connection with the further embodiments of the antenna, the antenna arrangement and the motor vehicle according to the invention. Thus, the corresponding further embodiments of the method according to the invention are not described again here.

[0033] The invention also comprises combinations of the features of the described implementations.

[0034] For use cases or use situations which may arise in the method and which are not explicitly described here, it may be provided that, in accordance with the method, an error message and/or a prompt for user feedback is output and/or a default setting and/or a predetermined initial state is set.

[0035] Examples of embodiments of the invention are described below. Therein,

Fig. 1 shows schematically a motor vehicle with an exemplary implementation of an antenna according to the invention;

Fig. 2 shows schematically a perspective view of a further exemplary implementation of an antenna according to the invention;

Fig. 3 shows schematically a top view of a further exemplary implementation of an antenna according to the invention;

Fig. 4 shows schematically a front view of the antenna according to Fig. 3;

Fig. 5 shows schematically a side view of the antenna according to Fig. 3;

Fig. 6 shows schematically a side view of an exemplary implementation of an antenna arrangement according to the invention;

Fig. 7 shows schematically a top view of the antenna arrangement of Fig. 6; and

Fig. 8 shows schematically a perspective view of a further exemplary implementation of an antenna according to the invention.

[0036] The examples of embodiments explained below are preferred examples of embodiments of the invention. In the examples of embodiment, the components described each represent individual features of the invention which are to be considered independently of one another and which each also further the invention independently of one another and are thus also to be regarded as a component of the invention individually or in a combination other than that shown. Furthermore, the described embodiments can also be supplemented by further of the already described features of the invention.

[0037] In the figures, functionally identical elements are each provided with the same reference signs.

[0038] Fig. 1 shows schematically a motor vehicle 1 with an exemplary implementation of a antenna 4 according to the invention. The antenna 4 may, for example, be integrated into a body part 9 of the motor vehicle 1, for example a bumper or grille.

[0039] The motor vehicle 1 may, for example, comprise an electronic control unit 3 or another computing unit for controlling the antenna 4 and/or for receiving data from the antenna 4.

[0040] The antenna 4 is for example a radar antenna. The following explanations, however, carry over analogously to other types of antennas. The antenna 4 is implemented as a waveguide antenna, for example an aperture antenna, as the horn type aperture antenna shown schematically in Fig. 2, or a slotted waveguide antenna, as shown in the exemplary implementation schematically in Fig. 8.

[0041] The antenna 4 comprises a waveguide component 5, which may constitute a housing part of the antenna. The waveguide component 5 comprises a plastic part 6, which is partly galvanized or metallized such that a metal layer is formed on an inner surface 7 of the plastic part 6, which guides electromagnetic waves 11 (see Fig. 3) from a target region 8 into an outer environment of the antenna 4 and/or from the outer environment to the target region 8. A receiver and/or transmitter device 10, in particular a wave source for electromagnetic waves 11 and/or a receiver chip for receiving the electromagnetic waves 11, may be arranged at the target region 8.

[0042] The thickness of the metal layer is, for example, equal to or greater than a penetration depth of the material of the metal layer, for example silver, for a predefined frequency of the electromagnetic waves. The penetration depth may in an exemplary use case, for example, be 0.23 micrometers. In general, the penetration depth depends on the frequency of the electromagnetic waves 11. The thickness of the metal layer is consequently chosen such that for a predefined reference frequency, which may, for example, lie within the range 10 gigahertz to 100 gigahertz, the thickness is greater than or equal to the penetration depth.

[0043] Several aspects of further exemplary implementations of a antenna 4 according to the invention are described with reference to Fig. 3 to Fig. 5. Therein, the example of a horn antenna is chosen, however, the explanations carry over analogously to other waveguide antennas, in particular other types of aperture antennas or travelling wave antennas.

[0044] Fig. 3 shows a top view of an exemplary implementation of the antenna 4 with a wave source chip 10 mounted at the target region 8.

[0045] The waveguide component 5 comprises the plastic part 6 providing mechanical support and the possibility for a simple mounting to the body part 9. The electrically relevant part for guiding the electromagnetic waves 11 is constituted by the metal layer on the inner surface 7. Due to the mechanical support by the plastic part 6, the metal layer can be designed very thin. Fig. 4 shows the antenna 4 in a front view and Fig. 5 shows the antenna 4 in a side view.

[0046] In some implementations, the plastic part 6 comprises latching lugs 12 on an outer side for mounting the antenna 4 to the body part. An exemplary implementation of an antenna arrangement 13 according to the invention with such a antenna 4 is shown in a schematic side view in Fig. 6 and in a corresponding schematic top view in Fig. 7, where the body part 9 is a grille of the motor vehicle 1. Furthermore, also a radome (not shown) can be applied to tune the dielectric constant.

[0047] Based on the antenna type, dimensions and requirements of mechanical parts may vary. For example, the dimensions of a horn antenna (for example 7x1.5x5 mm in a specific non-limiting use case) may be smaller than those of a slotted waveguide antenna (for example 50x12x20 mm in a specific non-limiting use case).

[0048] As described, in particular with respect to the figures, the invention provides a galvanized or metallized antenna, which may for example be integrated into body parts, in particular plastic body parts, of a motor vehicle. The antenna may be used in different frequency bands including radar bands such as LRR and SRR.

[0049] The plastic body parts of the motor vehicle, such as grille or bumper, may be manufactured by means of an injection molded process, which allows for very precise dimensions.

Reference signs

[0050]

1 motor vehicle
3 electronic control unit
4 antenna
5 waveguide component
6 plastic part

7 inner surface
8 target region
9 body part
10 receiver and/or transmitter device
11 electromagnetic waves
12 latching lugs
13 antenna arrangement

Claims

1. Antenna (4) for a motor vehicle (1), the antenna (4) comprising a waveguide component (5) and a target region (8) for positioning a receiver and/or transmitter device (10),
characterized in that
the waveguide component (5) comprises a plastic part (6) and an inner surface (7) of the plastic part (6) for guiding electromagnetic waves (11) from the target region (8) into an outer environment of the antenna (4) and/or from the outer environment to the target region (8) comprises a galvanized or metallized metal layer.

2. Antenna (4) according to claim 1,
characterized in that
a thickness of the metal layer is equal to or greater than a penetration depth of a material of the metal layer for a predefined frequency of the electromagnetic waves (11).

3. Antenna (4) according to claim 2,
characterized in that
the thickness is less than 100 times the penetration depth or less than 50 times the penetration depth or less than 20 times the penetration depth or less than 10 times the penetration depth.

4. Antenna (4) according to one of claims 2 or 3,
characterized in that
the predefined frequency lies within the range [10 GHz, 100GHz].

5. Antenna (4) according to one of the preceding claims,
characterized in that
the metal layer is made of silver or a silver alloy or copper or a copper alloy.

6. Antenna (4) according to one of the preceding claims,
characterized in that
the antenna (4) is an aperture antenna or a travelling wave antenna or a slotted waveguide antenna.

7. Antenna (4) according to one of the preceding claims,
characterized in that
the antenna (4) comprises the receiver and/or transmitter device (10), which is arranged in the target region (8).

8. Antenna arrangement (13) for a motor vehicle (1) comprising an antenna (4) according to one of the preceding claims and a body part (9) for the motor vehicle (1), wherein the antenna (4) is fastened to the body part (9).

9. Antenna arrangement (13) according to claim 8,
characterized in that
the antenna (4) is fastened to the body part (9) by means if a clip connection.

10. Antenna arrangement (13) according to one of claims 8 or 9,
characterized in that
the body part (9) is a bumper or a grille for the motor vehicle (1).

11. Motor vehicle (1) comprising an antenna (4) according to one of claims 1 to 7 or an antenna arrangement (13) according to one of claims 8 to 10.

12. Method for manufacturing an antenna (4) according to one of claims 1 to 7, wherein the waveguide component (5) is provided and the metal layer is generated by galvanizing or metallizing the inner surface (7) of the plastic part (6).

13. Method according to claim 12,
characterized in that
the plastic part (6) is produced by injection molding or an extrusion process.

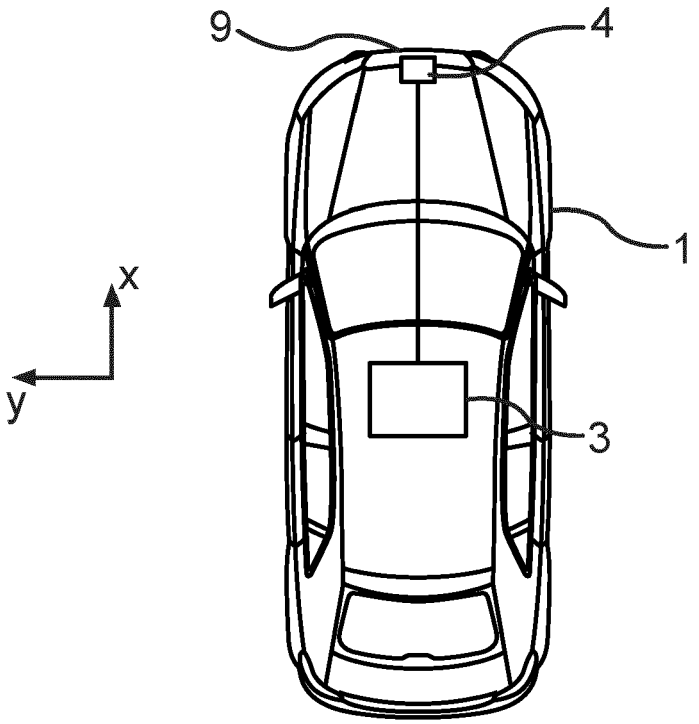

Fig.1

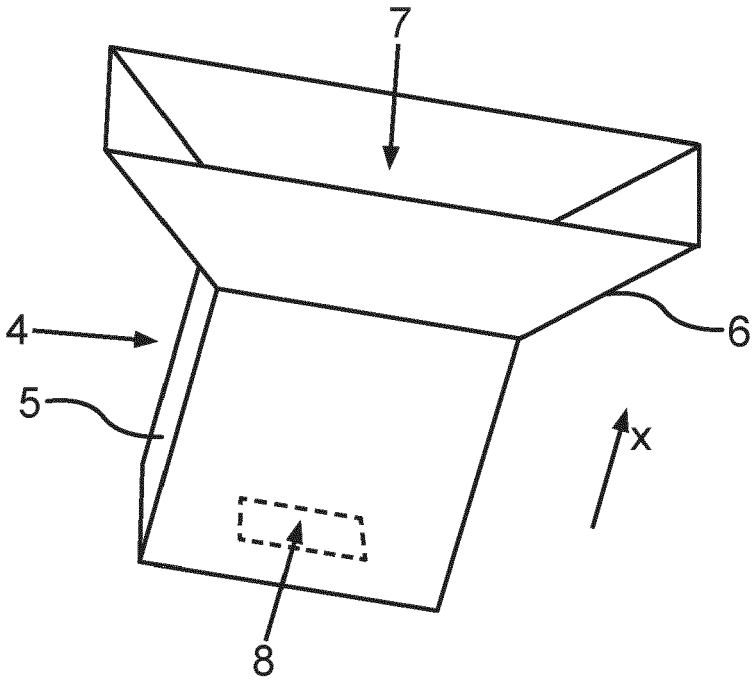

Fig.2

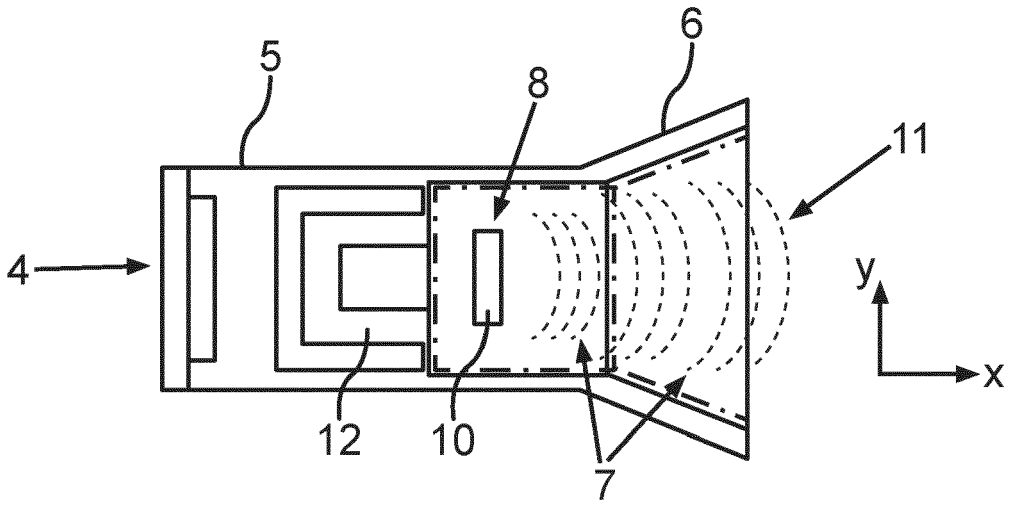

Fig.3

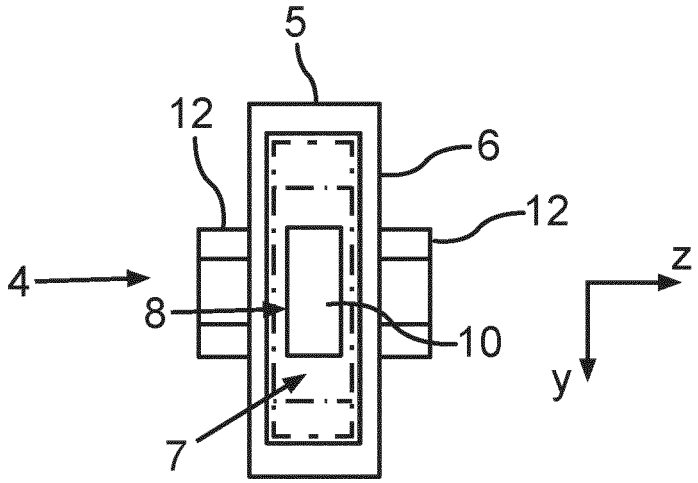

Fig.4

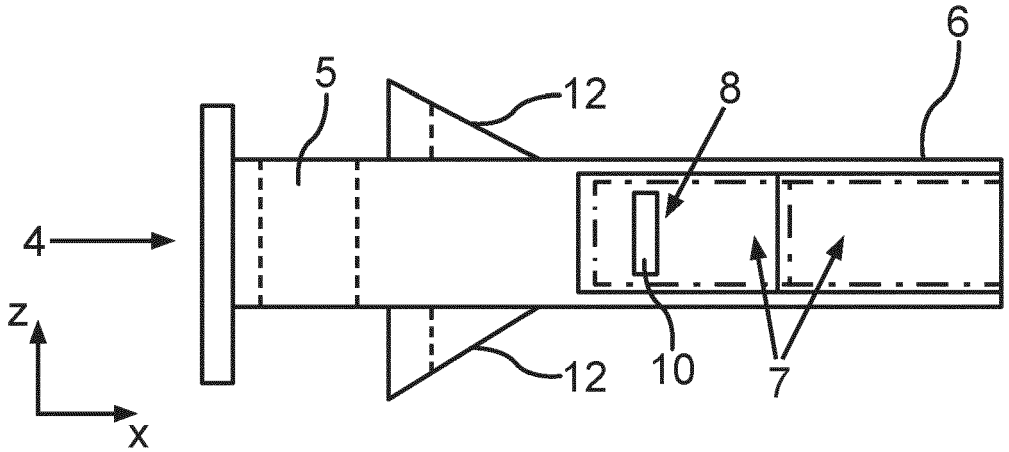

Fig.5

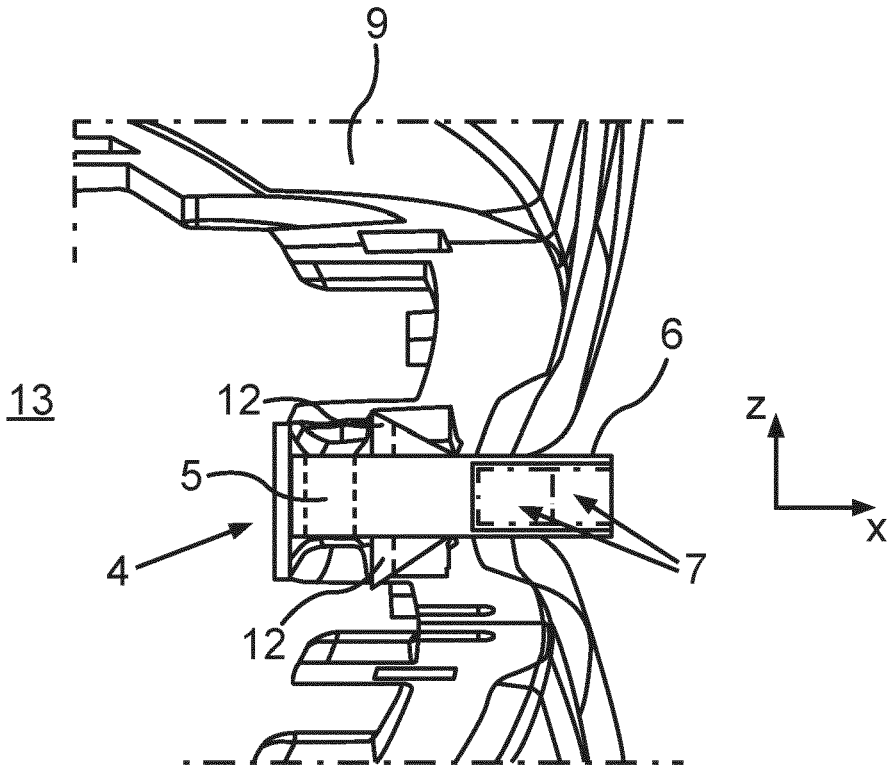

Fig.6

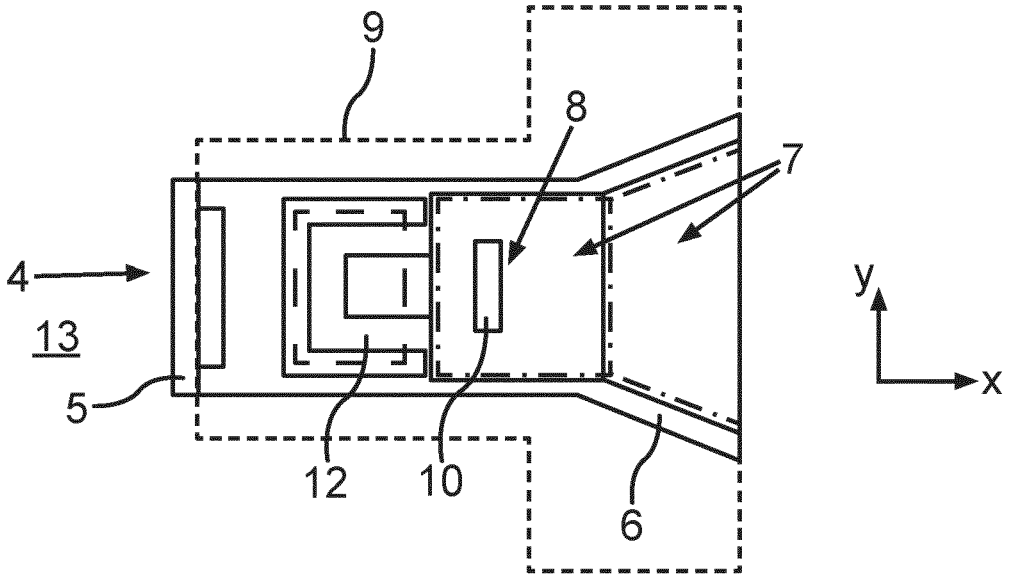

Fig.7

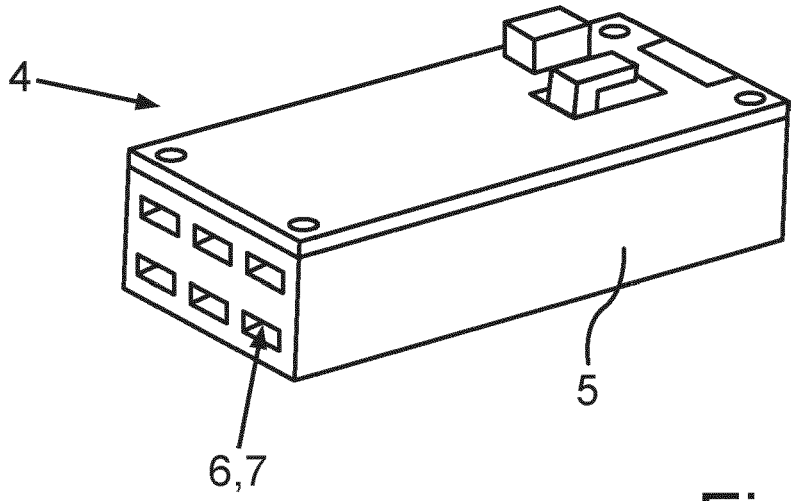

Fig.8

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 3432

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2019/198985 A1 (SELER ERNST [DE] ET AL) 27 June 2019 (2019-06-27) * paragraphs [0002] - [0053]; figures 1-6 * -----	1,2,4-8, 10-13 9	INV. H01Q1/32 H01Q13/02 H01Q21/00
X	HUANG GUAN-LONG ET AL: "Lightweight Perforated Waveguide Structure Realized by 3-D Printing for RF Applications", IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION, IEEE, USA, vol. 65, no. 8, 1 August 2017 (2017-08-01), pages 3897-3904, XP011658152, ISSN: 0018-926X, DOI: 10.1109/TAP.2017.2715360 [retrieved on 2017-08-03] * pages 1-8; figures 1-19 * -----	1,2,4,6, 7,12	
X Y	US 10 454 158 B2 (WAYMO LLC [US]) 22 October 2019 (2019-10-22) * columns 1-15; figures 1-6 * -----	1-8, 10-13 9	
X	GREGORY PETER LE SAGE: "3D Printed Waveguide Slot Array Antennas", IEEE ACCESS, vol. 4, 21 March 2016 (2016-03-21), pages 1258-1265, XP055532428, DOI: 10.1109/ACCESS.2016.2544278 * pages 1-8; figures 1-14 * -----	1-7,12	TECHNICAL FIELDS SEARCHED (IPC) H01Q
Y	DE 10 2017 210291 A1 (CONTINENTAL AUTOMOTIVE GMBH [DE] ET AL.) 20 December 2018 (2018-12-20) * paragraphs [0002] - [0071]; figures 1-6 * ----- -/--	9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	23 November 2023	El-Shaarawy, Heba

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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EUROPEAN SEARCH REPORT

Application Number
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2018/290612 A1 (IKENO EISUKE [JP]) 11 October 2018 (2018-10-11) * paragraphs [0003] - [0053]; figures 1-5 *	1-13	
A	EP 0 957 371 B1 (SIEMENS AG [DE]) 28 January 2004 (2004-01-28) * paragraphs [0001] - [0038]; figures 1-5 *	1-13	
			TECHNICAL FIELDS SEARCHED (IPC)

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23-11-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2019198985 A1	27-06-2019	EP 3506424 A1	03-07-2019
		US 2019198985 A1	27-06-2019
US 10454158 B2	22-10-2019	CN 109478724 A	15-03-2019
		EP 3491698 A1	05-06-2019
		JP 6909851 B2	28-07-2021
		JP 7195296 B2	23-12-2022
		JP 2019527508 A	26-09-2019
		JP 2021002887 A	07-01-2021
		KR 20190021494 A	05-03-2019
		KR 20190111156 A	01-10-2019
		KR 20200054341 A	19-05-2020
		KR 20210012059 A	02-02-2021
		US 2018034140 A1	01-02-2018
		US 2019109372 A1	11-04-2019
		US 2020014100 A1	09-01-2020
		US 2021036411 A1	04-02-2021
		WO 2018022295 A1	01-02-2018
DE 102017210291 A1	20-12-2018	NONE	
US 2018290612 A1	11-10-2018	CN 108688612 A	23-10-2018
		EP 3385126 A1	10-10-2018
		JP 6805942 B2	23-12-2020
		JP 2018176885 A	15-11-2018
		US 2018290612 A1	11-10-2018
EP 0957371 B1	28-01-2004	DE 19820708 A1	25-11-1999
		EP 0957371 A2	17-11-1999

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