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(71) Applicant: **Continental Automotive GmbH
30165 Hannover (DE)**

(72) Inventors:
- **Hadarig, Andreea
81737 München (DE)**
- **Schuehler, Mario
81737 München (DE)**

(74) Representative: **Continental Corporation
c/o Continental Automotive GmbH
Intellectual Property
Postfach 83 01 16
81701 München (DE)**

(54) ANTENNA ARRANGEMENT WITH ENHANCED BANDWIDTH

(57) The invention relates to the field of antennas, particularly to an antenna arrangement (10) for mobile communication antennas. The antenna arrangement (10) comprises a main antenna (20) and an auxiliary antenna (30). The auxiliary antenna (30) is electromagnetically coupled with the main antenna (20) within a coupling region (40), to have a broader bandwidth of the antenna arrangement (10), compared to a bandwidth of the main antenna (20).

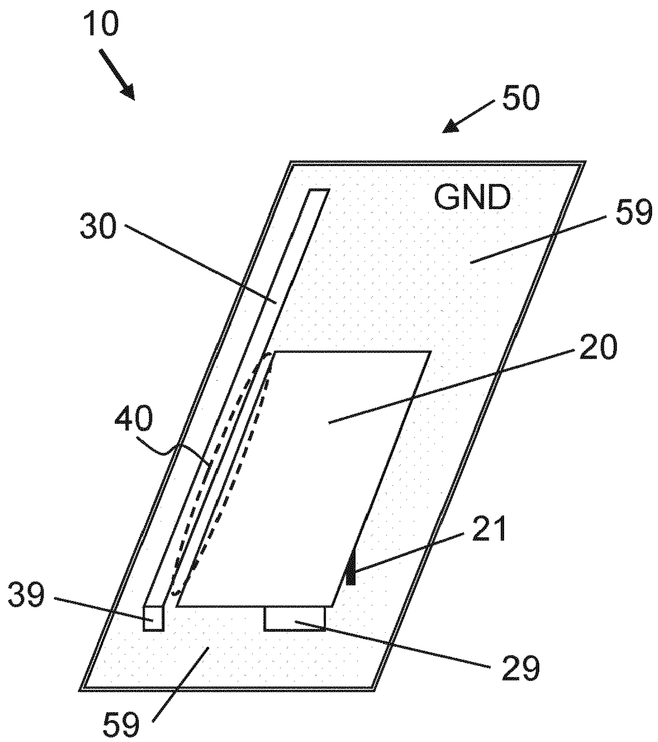

Fig. 1

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Description

Field of the Invention

[0001] The invention relates to the field of antennas, particularly for mobile communication antennas. The invention further relates to a use and a vehicle with such an antenna.

Background

[0002] At least some antennas designed for mobile communication need to cover multiple standards and/or multiple frequency bands, for instance 3G and/or 4G bands (3G and 4G relate to the so-called "third" or "fourth" generation of mobile communication standards, respectively). In addition, for some applications may be a demand for reducing the dimensions of antennas. At least for some type of antennas, this may become difficult when going to lower frequencies.

Description

[0003] It is therefore an objective of the invention to provide an improved antenna, particularly suitable for mobile communication. This objective is achieved by the subject-matter of the independent claims. Further embodiments are evident from the dependent patent claims and the following description.

[0004] One aspect relates to an antenna arrangement that comprises a main antenna and an auxiliary antenna. In this antenna arrangement, the auxiliary antenna is electromagnetically coupled with the main antenna within a coupling region, to have a broader bandwidth of the antenna arrangement, compared to a bandwidth of the main antenna.

[0005] The main antenna may be of any type, particularly of types suitable for frequencies around 2 GHz, or between 1 GHz and 5 GHz. Antenna types may comprise, but are not limited to planar antennas, printed antennas, etc., and/or special types like, e.g., planar inverted-F antennas, PIFA. The auxiliary antenna may be of any type. In some embodiments, the auxiliary antenna may be of a smaller size, e.g. of a smaller width, than the main antenna. The dimensions of the auxiliary antenna, for instance its length, may be determined by its center frequency and/or its border frequency. The auxiliary antenna is electromagnetically coupled with the main antenna, e.g. by an inductive and/or capacitive coupling. The coupling may have effects like "blending" the antennas' resonance frequencies.

[0006] There is essentially no resistive coupling between the main antenna and the auxiliary antenna, particularly there is no "conductive touching" between them. Thus, the major part of the energy transferred by this coupling is transferred within the so-called coupling region, where the antennas are in close (not-conductive) contact. The coupling may be done at an arbitrary position of the antennas. This advantageously gives a degree of freedom in shaping the frequency response of the impedance measured at the feeding point. For instance, the auxiliary antenna may be positioned alongside, besides, over, under, and/or overlapping with the main antenna. The positioning and/or the measures of the antennas may depend on the frequency range to be achieved and/or the desired impedance of the antenna arrangement.

[0007] By this means, the antenna arrangement achieves a broader bandwidth than the bandwidth that is achieved by only the main antenna. When using the antenna arrangement for mobile communication, multiple frequency bands may be supported. In some embodiments, the antenna arrangement may be suitable to cover a range comprising at least parts of 1G systems, 2G (GSM) systems, 3G (UMTS), 4G (LTE) systems, and/or 5G systems, (evolving) 6G systems, and/or further, possibly including future, mobile communication systems. Some of these systems may allow high data rate communication. Moreover, the antenna arrangement can be compacter than at least some other antenna solution. In addition, the antenna arrangement may be advantageously providing means for cost-effective manufacturing of an antenna system. This solution may be well-suited particularly for use in vehicles.

[0008] In various embodiments, the broader bandwidth of the antenna arrangement broadens the bandwidth, compared to a bandwidth of the main antenna, towards lower frequencies. This is particularly advantageous, because this may reduce the size of an antenna and/or antenna arrangement significantly, compared to other solutions.

[0009] In some embodiments, the main antenna has a bandwidth ranging from 1 GHz to 5 GHz and the antenna arrangement has a bandwidth ranging from 400 MHz to 5 GHz, particularly from 600 MHz to 5 GHz, particularly from 800 MHz to 5 GHz. This is advantageously well-suited for a broad range of communication types, for instance for audio communication, such as telephone applications, for videos, for games, and/or for signals that are configured to steer a vehicle, particularly an at least partly automated vehicle.

[0010] In some embodiments, the broader bandwidth of the antenna arrangement broadens the bandwidth, compared to a bandwidth of the main antenna, towards higher frequencies. This may advantageously reduce a size of a complete antenna system.

[0011] In various embodiments, the length of the auxiliary antenna is $\lambda/4$ of the border frequency and/or of the center frequency of the broader bandwidth of the antenna arrangement. This may contribute to a good adaptation of the antenna arrangement.

[0012] In various embodiments, the auxiliary antenna receives energy exclusively from the main antenna. The energy-transfer takes place essentially only via the coupling region. This may contribute significantly to a compact, easy-to-handle, and/or cost-sensitive manufacturing of the antenna system. It may be particularly advantageous that no additional source of energy is required, due to this.

[0013] In various embodiments, both a main antenna ground of the main antenna and an auxiliary antenna ground of the auxiliary antenna are connected to a common ground. The common ground of both antennas may be realized, e.g., by the common ground of a printed circuit board, PCB, and/or a common ground of the vehicle, a common piece of tin, and/or other implementations. This contributes to well-defined attributes or properties, e.g. electrical properties, of the antenna arrangement.

[0014] In some embodiments, a distance between the auxiliary antenna an the main antenna is between 0.001 mm and 100 mm, particularly between 0.01 mm and 10 mm, particularly between 0.1 mm and 2 mm. These ranges may both contribute to good - e.g. efficient - properties and to a compact design of the antenna system.

[0015] In various embodiments, the coupling region comprises a dielectric, wherein the dielectric comprises a group of materials, which comprises air, resin, ceramics, and/or plastics, e.g. silicone, rubber. These implementation details give rise to a broad range of well-adapted designs, i.e. for a broad range of applications.

[0016] In various embodiments, a main antenna surface and/or edge (or rim) of the main antenna and/or an auxiliary antenna surface and/or edge (or rim) of the auxiliary antenna have at least one of the following shapes: flat, triangular, rectangular, polygonal, round, elliptic, and/or sinusoidal. The triangular may include symmetric forms, asymmetric forms like saw tooth, and further ones. The same may apply to other polygonal forms. The sinusoidal forms may include a sine-form, possibly combined with forms of higher spatial frequency. A general idea of these forms may be to advantageously be able to vary the inductive and/or the capacitive part of the coupling, e.g. for better impedance adaptation and/or for a more efficient energy transfer between the antennas.

[0017] In some embodiments, a first contour of the main antenna surface overlaps with a second contour of the auxiliary antenna surface. "Contour overlapping" does not mean that the antennas touch, but rather that one antenna gets into a gap of the other one. For instance, a "triangle top" of the one antenna may "dive" into a "triangle valley" of the other antenna. This may contribute to a particularly efficient energy transfer between the antennas, particularly to the auxiliary antenna.

[0018] In some embodiments, the main antenna is one of: a planar antenna, a printed antenna, a planar inverted-F antenna, PIFA, and/or a capacitively loaded monopole. This may contribute to a well-adapted solution for a broad range of applications.

[0019] A further aspect relates to a use of an antenna arrangement according to any one of the preceding claims for high data rate communication, particularly for 1G, 2G, 3G, 4G, and/or 5G based communication systems, for a telematic control unit, for an intelligent antenna module, a smart antenna module, and/or for an antenna module that may be separated from an telematic control unit.

[0020] A further aspect relates to a vehicle with an antenna arrangement as described above and/or below.

[0021] For further clarification, the invention is described by means of embodiments shown in the figures. These embodiments are to be considered as examples only, but not as limiting.

Brief Description of the Drawings

[0022] The figures depict:

Fig. 1	schematically an antenna arrangement according to an embodiment;
Fig. 2	one example of dimensioning an antenna arrangement according to an embodiment;
Fig. 3	schematically an antenna arrangement according to an embodiment;
Fig. 4	schematically an antenna arrangement according to a further embodiment;
Fig. 5	schematically an antenna arrangement according to a further embodiment;
Fig. 6a and 6b	schematically examples of antenna surfaces within the coupling region.

Detailed Description of Embodiments

[0023] Fig. 1 schematically shows an antenna arrangement 10 according to an embodiment. The antenna arrangement 10 is arranged on a PCB (Printed Circuit Board) 50, with a common ground 59. On the PCB 50, a main antenna 20 and an auxiliary antenna 30 is arranged. Both a main antenna ground 29 of the main antenna 20 and an auxiliary antenna ground 39 of the auxiliary antenna 30 are connected to the common ground 59 of the PCB 50. The main antenna 20 is fed via a feed point 21 with radio-frequency (RF) signals. The main antenna 20 transfers energy to the auxiliary antenna 30 via a coupling region 40. The auxiliary antenna 30 is electromagnetically coupled with the main antenna 20 within the coupling region 40. Thus, the auxiliary antenna 30 receives energy essentially exclusively from the main antenna 20, via the coupling region 40. Thus, the antenna arrangement 10 has a broader bandwidth, compared to a bandwidth of the main antenna 20. The length of the auxiliary antenna 30 is $\lambda/4$ of the border frequency and/or of the center frequency of the broader bandwidth of the antenna arrangement 10. Additionally, or alternatively, the coupling region may be shaped in different manners and at different positions, thereby allowing a certain degree of freedom when implementing the antenna arrangement.

[0024] Fig. 2 one example of dimensioning an antenna arrangement 10 according to an embodiment. This dimensioning is only shown to give an idea of the measures of an implementation. The antenna arrangement 10 is sited on a PCB 50, with example dimensions of 179 mm x 101 mm. The PCB 50 has, at least partly, a ground layer 59. On the bottom right corner region, a main antenna 20, dimensioned 40 mm x 23 mm, is sited. The main antenna 20 is fed with RF-signals via feed point 21. The main antenna 20 is electromagnetically coupled with an auxiliary antenna 30 and transfers energy, essentially exclusively via the coupling region 40, to the auxiliary antenna 30. This antenna system 10 is designed for a bandwidth ranging from 600 MHz to 5 GHz, wherein the main antenna 20 has only a bandwidth ranging from 1 GHz to 5. Hence, Fig. 2 provides a good idea of the small and compact dimensions of an antenna arrangement 10 described above and/or below.

[0025] Fig. 3 schematically depicts an antenna arrangement 10 according to an embodiment. A main antenna 20, fed via feed point 21, transfers energy to an auxiliary antenna 30. The broken lines give a rough idea of the coupling region 40, via which the energy is transferred. The auxiliary antenna 30 is designed similar to an L and is positioned alongside or besides the main antenna 20. The auxiliary antenna 30 has a ground pin 39 on one end; the other end is free. The auxiliary antenna's ground pin 39 is electrically connected (e.g. via a common ground, not shown) with a ground pin 29. The length of the auxiliary antenna 30 is $\lambda/4$ of the border frequency and/or of the center frequency of the broader bandwidth of the antenna arrangement 10.

[0026] Fig. 4 schematically shows an antenna arrangement 10 according to a further embodiment. A main antenna 20 is quite similar to the one shown, e.g., in Fig. 3. An auxiliary antenna 30 is designed similar to an L but has its ground pin 39 sited on a different end as shown in Fig. 3 and overlaps in some areas with the main antenna 20. The broken lines give, in a very schematic way, an idea of the coupling region 40. The length of the auxiliary antenna 30 is $\lambda/4$ of the border frequency and/or of the center frequency of the broader bandwidth of the antenna arrangement 10.

[0027] Fig. 5 schematically shows an antenna arrangement 10 according to a further embodiment. A main antenna 20 is quite similar to the one shown, e.g., in Fig. 3. An auxiliary antenna 30 is designed as a broad, folded sheet. It is sited below the main antenna 20 in an overlapping way. Hence, the coupling region 40 is below the main antenna 20, too. The length of the auxiliary antenna 30 is $\lambda/4$ of the border frequency and/or of the center frequency of the broader bandwidth of the antenna arrangement 10.

[0028] The examples of Fig. 1, 3, 4, and 5 provide an idea of variations of an antenna arrangement 10. The implementation of antenna arrangement 10 may depend on further specifications, for example on desired impedance, performance, bandwidth, and/or other factors.

[0029] Fig. 6a and 6b schematically depicts examples of antenna surfaces 25 and 35 within the coupling region 40. In Fig. 6a, the surface 35 of an auxiliary antenna 30 is designed as flat, whereas the surface 25 of a main antenna 20 has rectangular elements. In Fig. 6a, a contour of the surface 35 of coincides with surface 35, and a contour 26 of the surface 25 is on top of the rectangular elements of main antenna 20. The contours do not overlap.

[0030] In Fig. 6b, both the surface 35 of an auxiliary antenna 30 and the surface 25 of a main antenna 20 has rectangular elements. It can be seen clearly, that contour 26 of the main antenna 20 overlaps with contour 36 of the auxiliary antenna 30. This may be advantageous for antenna arrangements, where a more inductive coupling is preferred. The different designs of the coupling region 40, as shown in Fig. 6a and 6b, may advantageously influence impedance, transfer loss, and/or other properties of the coupling region 40. Depending on factors like frequency band, design restrictions, and others, the form-examples of Fig. 6a and/or 6b could - alternatively or additionally - be applied to edges of the main antenna 20 and/or of the auxiliary antenna 30.

[0031] The coupling region 40 may, for instance, consist of air, as a dielectric. Additionally, or alternatively, the coupling region may comprise air, resin, ceramics, and/or plastics, e.g. silicone, rubber.

Claims

1. An antenna arrangement (10) comprising:

   a main antenna (20) and
   an auxiliary antenna (30),
   wherein the auxiliary antenna (30) is electromagnetically coupled with the main antenna (20) within a coupling region (40), to have a broader bandwidth of the antenna arrangement (10), compared to a bandwidth of the main antenna (20).

2. The antenna arrangement (10) of claim 1, wherein the broader bandwidth of the antenna arrangement (10) broadens the bandwidth, compared to a bandwidth of the main antenna (20), towards lower frequencies.

3. The antenna arrangement (10) of claim 2, wherein the main antenna (20) has a bandwidth ranging from 1 GHz to 5 GHz and the antenna arrangement (10) has a bandwidth ranging from 400 MHz to 5 GHz, particularly from 600 MHz to 5 GHz, particularly from 800 MHz to 5 GHz.

4. The antenna arrangement (10) of claim 1, wherein the broader bandwidth of the antenna arrangement (10) broadens the bandwidth, compared to a bandwidth of the main antenna (20), towards higher frequencies.

5. The antenna arrangement (10) of any one of the preceding claims,
wherein the length of the auxiliary antenna (30) is $\lambda/4$ of the border frequency and/or of the center frequency of the broader bandwidth of the antenna arrangement (10).

6. The antenna arrangement (10) of any one of the preceding claims,
wherein the auxiliary antenna (30) receives energy exclusively from the main antenna (20).

7. The antenna arrangement (10) of any one of the preceding claims,
wherein both a main antenna ground (29) of the main antenna (20) and an auxiliary antenna ground (39) of the auxiliary antenna (30) are connected to a common ground (59).

8. The antenna arrangement (10) of any one of the preceding claims,
wherein a distance between the auxiliary antenna (30) an the main antenna (20) is between 0.001 mm and 100 mm, particularly between 0.01 mm and 10 mm, particularly between 0.1 mm and 2 mm.

9. The antenna arrangement (10) of any one of the preceding claims,
wherein the coupling region (40) comprises a dielectric, wherein the dielectric comprises a group of materials, which comprises air, resin, ceramics, and/or plastics, e.g. silicone, rubber.

10. The antenna arrangement (10) of any one of the preceding claims,
wherein a main antenna surface (25) and/or edge of the main antenna (20) and/or an auxiliary antenna surface (35) and/or edge of the auxiliary antenna (30) within the coupling region (40) has at least one of the following shapes: flat, triangular, rectangular, polygonal, round, elliptic, and/or sinusoidal.

11. The antenna arrangement (10) of claim 10,
wherein a first contour (26) of the main antenna surface (25) overlaps with a second contour (36) of the auxiliary antenna surface (35).

12. The antenna arrangement (10) of any one of the preceding claims,
wherein the main antenna (20) is one of: a planar antenna, a printed antenna, a planar inverted-F antenna, PIFA, and/or a capacitively loaded monopole.

13. Use of an antenna arrangement (10) according to any one of the preceding claims for high data rate communication, particularly for 1G, 2G, 3G, 4G, and/or 5G based communication systems, for a telematic control unit, for an intelligent antenna module, a smart antenna module, and/or for an antenna module that may be separated from an telematic control unit.

14. Vehicle with an antenna arrangement (10) according to any one of the claims 1 to 12.

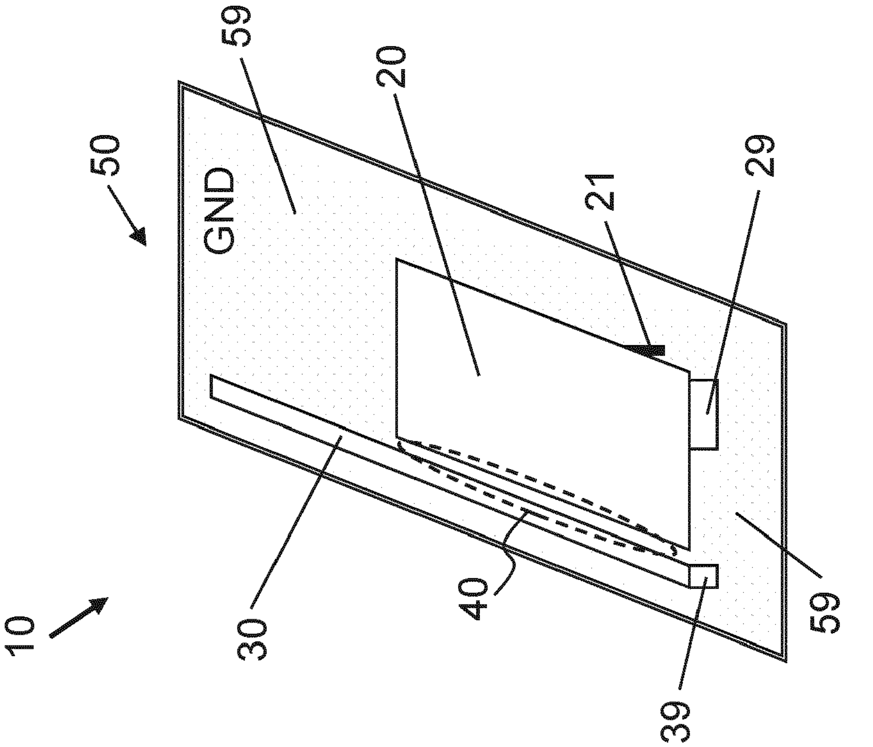

Fig. 1

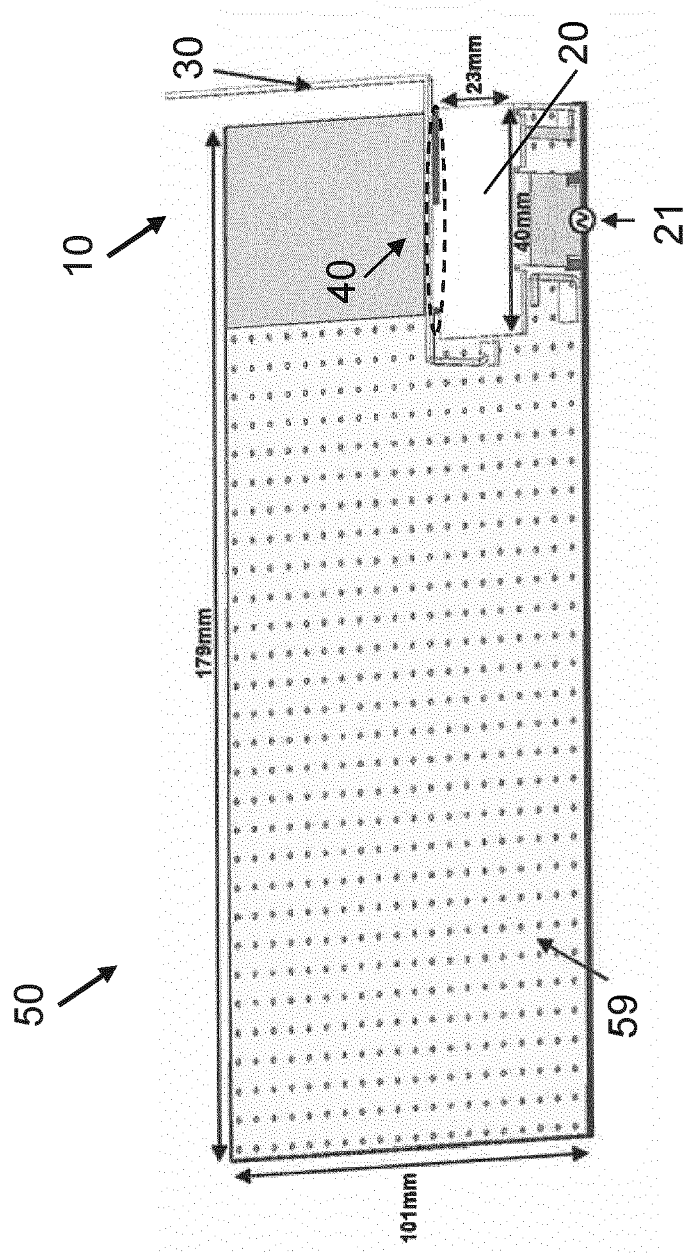

Fig. 2

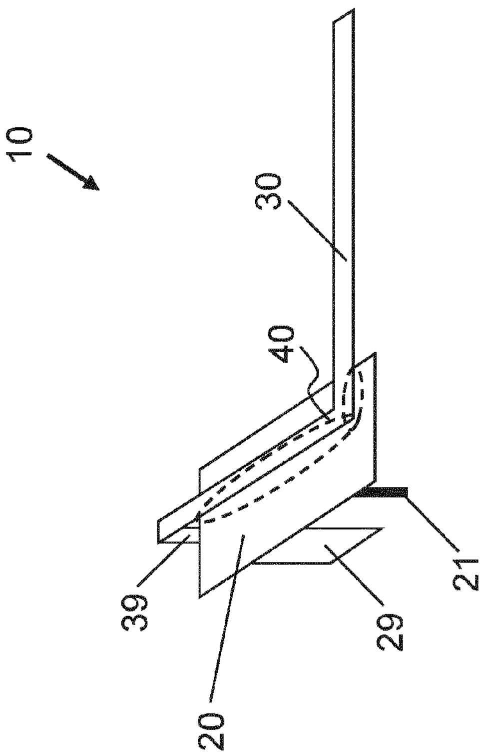

Fig. 4

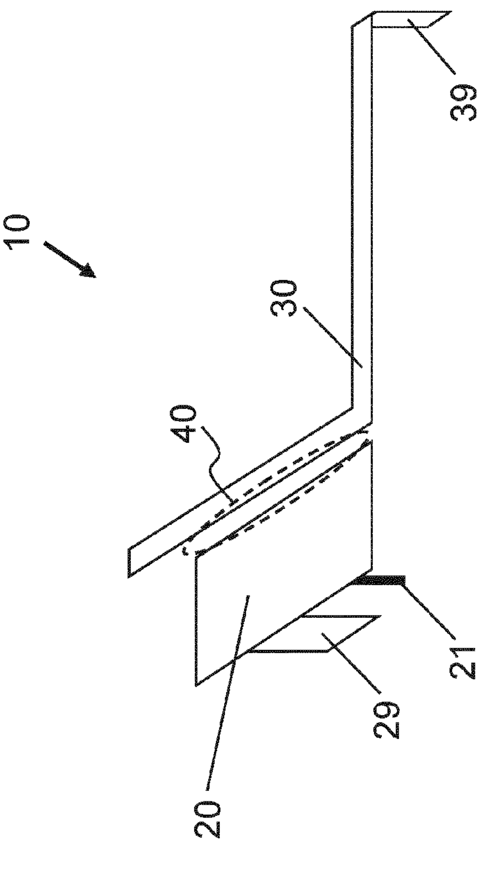

Fig. 3

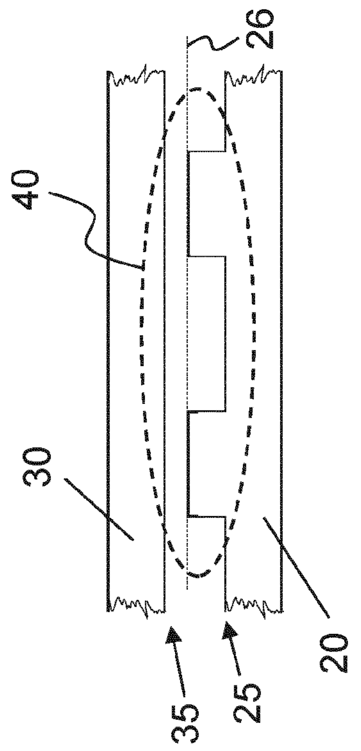

Fig. 6a

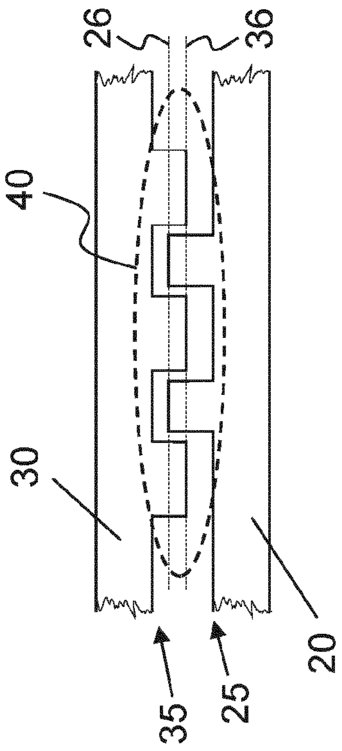

Fig. 6b

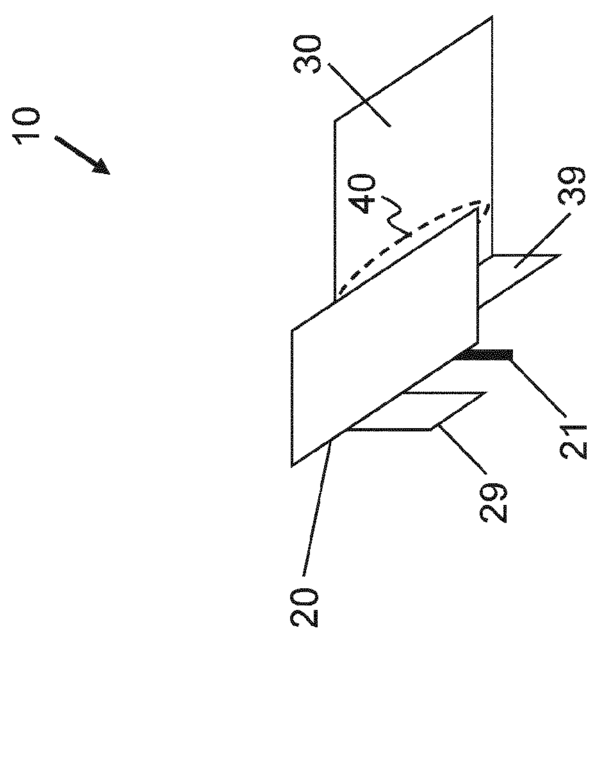

Fig. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 20 46 5508

DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 2015/380820 A1 (WU CHUN-YIH [TW] ET AL) 31 December 2015 (2015-12-31) * abstract; figures 1,2,4,5,6 * * paragraphs [0004] - [0008], [0028] - [0037] * -----	1,2,4-13	INV. H01Q1/24 H01Q9/04 H01Q19/00 ADD. H01Q1/32 H01Q9/42
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	4 August 2020	Hüschelrath, Jens

CATEGORY OF CITED DOCUMENTS

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