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(54) TWO-PART ANTENNA ELEMENT

(57) The invention relates to a radiating element for a base station antenna, comprising: a socket and a radiating part, wherein the socket has means for providing a mechanical support for the radiating part and microstrip lines of a feeding system for feeding the radiating part, and the radiating part is configured to be received by the socket and includes at least one pair of non-conductive slots in a conductive element, the slots being aligned to the microstrip lines of the feeding system when the radiating part is received by the socket, and wherein an outer circumference of the socket is less than a maximum outer circumference of the radiating part.

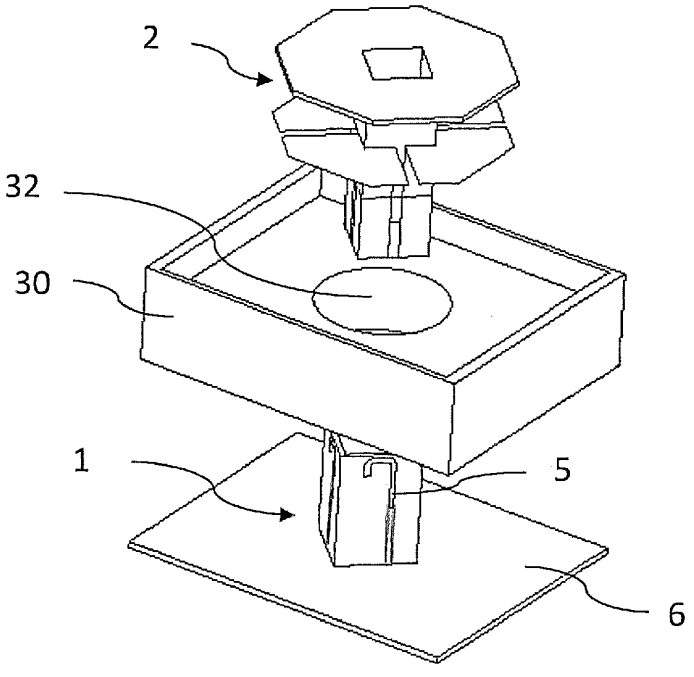


FIG. 3

EP 3 236 531 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a radiating element for a base station, an antenna including the radiating element, and to a method for manufacturing the antenna.

BACKGROUND

[0002] Base station antennas of the newest generation, such as of 5G mMIMO (massive Multiple Input Multiple Output) base stations will be fairly different as compared to traditional base-station antenna panels. The complete antenna arrays should be manufactured through a fully automated process, preferably compatible with the standards of PCB (Printed Circuit Board) manufacturing processes.

[0003] The employed antenna elements should occupy a minimum possible area and should be available for integrating on a multi-layer PCB, on which active radio frequency circuitry (electronic components) might be also installed. In case that a radio frequency shielding cover is used on the PCB to shield the aforementioned active radio frequency circuitry, the opening of the shielding cover should be minimal, so as to maximize the area of the PCB on which active circuitry can be installed. However, in order to install a radiating element on the same PCB, the shielding box should have an opening having the dimension of at least the outer circumference of the radiating element. An example is shown in WO 2013/123916 A1. Therein an active antenna system radio frequency module includes a heat sink and an RF shielding cover. The heat sink has an opening with a diameter large enough to affix a radiating element to the heat sink which also serves as antenna reflector. The opening must be large enough such that the radiating element can be placed inside the opening.

[0004] However, in order to optimize the available space for the electronic components and the RF shielding cover, it would be preferred to reduce the opening in the shielding box to a minimum in order to increase the total surface of the PCB available for electronic components. The radiating element should be installed and electrically connected to the electronic components using processes which are identical or similar to the assembling methods already used for the PCB, i.e. the standard PCB manufacturing processes such as pick-and-place SMT components, reflow, etc., in order to decrease the assembly complexity of the complete system.

[0005] As shown in WO 2013/123916 A1 these aims require a big opening in the RF shielding. Thus, there is a need for a radiating element and an antenna system as well as for a method of manufacturing the antenna which reduces the dimension of the system and decreases the manufacturing costs.

SUMMARY OF THE INVENTION

[0006] The objective of the present invention is to provide a radiating element for a base station, an antenna including the radiating element, and a method for manufacturing the antenna, which overcome one or more of the above-mentioned problems of the conventional solutions.

[0007] A first aspect of the invention provides a radiating element for a base station antenna, comprising: a socket and a radiating part, wherein the socket has means for providing a mechanical support for the radiating part and microstrip lines of a feeding system for feeding the radiating part, and the radiating part is configured to be received by the socket and includes at least one pair of non-conductive slots in a conductive element, the slots being aligned to the microstrip lines of the feeding system when the radiating part is received by the socket, and wherein an outer circumference of the socket is less than a maximum outer circumference of the radiating part. The two parts of the radiating element have different footprints. The radiating part has a larger diameter since it includes the dipole arms which minimum dimensions are typically limited by the operating wavelength of the radiating element. However, the socket which provides the feeding system for the radiating part of the radiating element can be constructed with a smaller footprint. The advantage of having such two-part antenna element is that the socket can be installed first on a PCB together with the electronic components as part of a common assembly process (e.g. SMT and reflow processes). Then, an electronic shielding can be installed on the electronic components before the radiating part of the radiating element is installed on the socket. In this way, conventional PCB manufacturing methods can be used to effectively assemble a system where the radiating part of the radiating element overlaps with the radio frequency shielding cover which is arranged close to the socket and below the radiating part of the radiating element. An opening in the radio frequency shielding can thereby kept small than the area occupied by the diploe arms of the radiating element. Typically such opening only needs to be large enough such that it can surround the socket.

[0008] In a first implementation of the radiating element according to the first aspect, the radiating part comprises a base portion and an extended portion, wherein the base portion is pluggable to the socket. Plugging the base portion to the socket can easily be performed by an automated robot within the process of assembling the PCB. Thus, this kind of connection between the radiating part and the socket is optimized for automated manufacturing. Further fixing means, e.g. a screw can be used to fix the radiating part after being plugged to the socket.

[0009] In a second implementation of the radiating element according to the first implementation of the first aspect, the extended portion defines the maximum outer circumference of the radiating part. An outer or inner circumference of the base portion is adapted to an inner or

outer circumference of the socket such that the base portion and the socket are nested when the base portion is received by the socket. To nest the base portion in the socket or above the socket has the advantage that the components are plugged together in the direction perpendicular to the structure where the socket is placed, in particular on a PCB. Thus, when connecting the base portion with the socket, the electronic components and the RF shielding installed around and close to the socket do not interfere in the connecting process.

[0010] In a third implementation of the radiating element according to the first or second implementation of the first aspect, the extended portion forms a main radiating part of the radiating element. As the extension of the dipole arms is related to the operating wavelength, the main radiating part of the radiating element cannot be smaller in size than the lateral minimum extension of the dipole arms. Thus, it is an advantage that the main radiating part of the radiating element is part of the extended portion of the radiating element.

[0011] In a fourth implementation of the radiating element according to any of the first to third implementation of the first aspect, each of the at least one of pair slots extend in the base portion and the extended portion of the radiating part. In this implementation, the slots extend into the base portion and the radiating portion. Thus, the feeding system can be simplified. The feeding system on the socket can directly feed the slots in the radiating portion via the part of the slots which extend in the base portion of the radiating part. The feeding of the slots in the radiating portion from the feeding system is occurring through electromagnetic coupling. No galvanic contact between the socket part and the radiating part is required, thus avoiding Passive Intermodulations (PIM).

[0012] In a fifth implementation of the radiating element according to any of the first to fourth implementation of the first aspect the socket and the base portion have congruent forms and, when plugged together, at least some part of the sidewalls of the base portion and the socket overlap with each other. The overlapping sidewalls of the base portion and the socket have the advantage that they can provide the mechanical connection between the base portion and the socket and at the same time the overlapping walls allow to electromagnetically couple the feeding system with the non-conductive slots as the feeding can take place from the part of the sidewall of the socket to the part of the sidewall of the base portion which overlap with each other.

[0013] In a sixth implementation of the radiating element according to the fifth implementation of the first aspect, the side walls of the socket carry the microstrip lines of the feeding system and the side walls of the base portions include a section of the at least one pair of slots. This implementation provides a simplified feeding system as the feeding system can be integrated onto the socket on these parts of the socket which overlap with the sidewalls of the base portion of the radiating element anyway.

[0014] In a seventh implementation of the radiating element according to any implementation of the first aspect, the radiating part is made of a molded interconnected device, MID, with partial materialization on an inner, an outer or both sides. MID is a preferred technology as it allows to easily manufacture the components of the radiating element in particular of the radiating part which includes the smaller base portion and the extended radiating portion in a single piece.

[0015] In an eighth implementation of the radiating element according to the first aspect or the first to sixth implementation of the first aspect, the radiating part is made of a solid metal part, in particular, of a stamped metal sheet. The non-conductive slots could be implemented by cut outs in the metal sheet.. The eighth implementation is an alternative to the seventh implementation. Also the solid metal material allows to easily manufacture the radiating element e.g. in a cutting and bending process of a metal sheet. The surface of the radiating part overlapping the socket should be insulated if the socket is also made of a metal sheet or is metalized on the inner side.

[0016] In a ninth implementation of the radiating element according to any implementation of the first aspect the socket carries the microstrip lines on an outer or inner surface and the radiating part, in particular with reference to the first implementation the base portion of the radiating part, is configured to be inserted into the socket or above the socket. The microstrip lines on the outer or inner surface of the radiating element allow a simple realization of the feeding system which preferably act together with the slots in the radiating part in particular in the base portion of the radiating part.

[0017] In a tenth implementation of the radiating element according to any implementation of the first aspect, the socket is made as a molded interconnect device, MID. MID technology is preferred as it allows to manufacture the structure of the socket and the conductive parts of the socket in a simplified manufacturing process.

[0018] In an eleventh implementation of the radiating element according to any implementation of the first aspect, the radiating element comprises an isolating sheet disposed between the contact surfaces of the radiating element and the socket at least in these areas, where the contact surfaces are conductive (e.g. metalized) on opposing sides. The insulating sheet galvanically disconnects the conductive parts of the feeding system from the conductive parts of the radiating elements.

[0019] In a twelfth implementation of the radiating element according to any implementation of the first aspect, the radiating part includes means for fixing the radiating part to the socket or to a support structure, in particular a printed circuit board, PCB, below the socket, or a part of a shielding cover / heat sink below the PCB. As in the completed radiating element the radiating part shall be permanently fixed to the socket of the radiating element or to a support structure such as a support structure of the completed antenna, the fixing means are pre-

ferred to hold the radiating part permanently in place.

[0020] A second aspect of the invention refers to an antenna including a printed circuit board, PCB, the radiating element of any implementation of the first aspect, and a radio frequency shielding, wherein the socket is electrically and mechanically connected to the PCB, the radiating part is received by the socket and the radio frequency shielding is provided in an area outside the outer circumference of the socket and inside the maximum outer circumference of the radiating element when projecting onto the layer of the PCB. Due to the two-part construction of the radiating element, it is possible according to the second aspect to arrange the radio frequency shielding closely to the socket such that parts of the radio frequency shielding are extending inside the maximal circumference of the radiating element. On in other words an opening of the radio frequency shielding can be kept smaller than the maximal circumference of the radiating element, when compared to conventional solutions. Thus, the space for arranging the radio frequency shielding is increased with respect to conventional constructions which need an open space (or opening) over the maximum dimension of the radiating element.

[0021] In a first implementation of the antenna of the second aspect, the radio frequency shielding includes an opening with a diameter larger than the socket and less than the diameter of the maximum outer circumference of the radiating element. Thus, the radio shielding can have a maximum spatial extension with respect to the radiating element of the antenna.

[0022] A third aspect of the invention refers to a method for manufacturing an antenna element of the second aspect or the first implementation of the second aspect of the invention, comprising the following steps: mechanically and electrically connecting the socket to the PCB, in particular through a standardized PCB assembly process (e.g. SMT and reflow); mounting the radio frequency shielding to the PCB surrounding the socket; and plugging the radiating part into the socket or putting the radiating part over the socket, at least in part, above the radio frequency shielding. The order of these method steps contributes to the invention because it allows to mount the radio frequency shielding before the radiating part is connected to the socket. Thus, the space below the radiating portion can be used for the RF shielding while assembling the antenna in a simplified process.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] To illustrate the technical features of embodiments of the present invention more clearly, the accompanying drawings provided for describing the embodiments are introduced briefly in the following. The accompanying drawings in the following description are merely some embodiments of the present invention, but modifications on these embodiments are possible without departing from the scope of the present invention as defined in the claims.

FIG. 1	shows a perspective view of a socket of a radiating element of a first embodiment,
FIG. 2a-b	show perspective views of the radiating part of the radiating element of the first embodiment in two different implementations,
FIG. 3	shows an exploded view of the radiating element of the first embodiment together with a radio frequency shielding,
FIGs 4a-d	show cross sections of an antenna of a second embodiment during the steps of manufacturing,
FIG. 5	shows a cross section of a third embodiment of an antenna, and
FIG. 6	shows a cross section of a fourth embodiment of an antenna.

Detailed Description of the Embodiments

[0024] Referring to FIGs 1 to 3, a first embodiment of a radiating element is described. The radiating element substantially includes two parts, a socket 1 as shown in FIG. 1 and a radiating part 2 as shown in FIG. 2. Those parts are configured to be mechanically connected by plugging a base portion 3 of the radiating part 2 into the socket 1. A skilled person will understand that other connections between the radiating element and the socket are also possible. For instance, the base portion 3 of the radiating part 2 may also be constructed to be put over the socket 1.

[0025] The radiating part 2 comprises mainly antenna radiating arms of a conductive material which are separated by non-conductive slots 4. The radiating part 2 can be produced either as a MID part with partial metallization as shown in FIG. 2a, or as a metallic part, stamped out of a metal sheet as shown in FIG. 2b. The socket 1 includes sidewalls and may also be manufactured as an MID part. The sidewalls include microstrip lines 5 which, when the parts are assembled together, are aligned to the slots 4 of the radiating part 2. Aligning means in this context that the microstrip lines 5 are arranged in a position with respect to the slots such that a feeding across the slots is possible. That is, the inner side of the socket 1 and the conductive part of the base portion 3 of the radiating part 2 should be galvanically or, preferably, capacitively coupled. The socket 1 can be connected to a printed circuit board, PCB, 6, as shown in FIG. 1. The PCB 6 includes conductive lines (not shown) to feed the microstrip lines on the socket 1.

[0026] Thus, the radiating element is split into two parts 1 and 2, one containing the feeding part and the other the radiating part. Thereby both parts provide an electrical function. This way of splitting the radiating element allows to keep the footprint on the PCB 6 smaller than

the maximum cross section of the radiating part 2 wherein the cross section is measured in a fictive layer which is parallel to the PCB 6. This has the particular advantage as described below.

[0027] As shown in FIG. 3, a radiofrequency shielding 30 may be assembled between the socket 1 and the radiating part 2 while having an opening 32 which circumferences the socket 1 and the base portion 3 of the radiating part 2 but which is in dimension smaller than the maximum circumference of the radiating part 2.

[0028] The socket 1 of the radiating element which forms a feeding part is designed to occupy the least possible footprint of the radiating element on the PCB 6 on which it is supposed to be soldered or reflowed as other electronic components 20. Due to the soldering, the connection between the active radio frequency system output and the antenna input is always stable from the viewpoint of impedance and phase. After connecting the electronic components 20 and the socket 1 to the PCB as shown in FIG. 4a, one or more radio frequency shielding covers or heat sinks are mechanically connected to the PCB 6. For example, a radio frequency shielding 30 or heat sink including a hole in the area of the socket 1 can be screwed on the PCB as shown in the upper part of FIG. 4b. The opposing side can also be shielded by connecting an RF shield with screws as shown in the lower part of FIG. 4b.

[0029] Once the RF shielding 30 or heat sink is connected to the PCB 6, the radiating part 2 of the radiating element can be installed in the socket 1 or put over the socket. As shown in FIG. 4c, the base portion 3 of the radiating part 2 can be installed inside the socket 1. To fix the radiating part 2 into the socket 1, the radiating part 2 can be connected 6 by means of a screw 42 which engages a heat sink / shielding on the opposite side of the PCB 6 as shown in FIG. 4d or by any other fastening means such as snapping features 43 which interact with the socket 1 as shown in FIG. 6.

[0030] A further embodiment is shown in FIG. 5. According to this embodiment, the socket 1 comprises a feeding system on both the outer and the inner side, and is soldered onto the PCB. An insulation tape 11 is brought between the socket 1 and the base portion 3 of the radiating part 2 in order to avoid galvanic connection. In this embodiment, there is a ground plane in the inner side of the socket 1. This ground plane has a non-conductive slot, identical with overlapping portion of the non-conductive slot of the radiating part.

[0031] If the radiating part is made of stamped metal or a metallization of a MID part is placed in the inner side, a DC short between the radiating part and the socket is implemented. To avoid a direct galvanic connection between the ground plane of the socket 1 and the metallization of the radiating part, a thin-film insulation tape may be used between the two parts 1 and 2.

[0032] In an alternative embodiment (as for example illustrated in Fig. 4d), the socket 1 may also comprise microstrip lines 5 on the outside but without a conductive plating on the inner side of the socket 1. In this case no insulation tape is required between the two parts of the radiating element. In this embodiment, the radiating part 2 is also used as a ground plane for the feeding microstrip lines 5. For this the radiating part 2 can be either galvanically connected (e.g. using the screw 42) to or capacitively coupled to the ground (plane) of the PCB 6.

[0033] FIG. 6 shows a further embodiment where the radiating part 2 is made either of stamped metal or of a metallized MID. It is fixed onto the socket 1 with snapping features 43 or can be glued. The socket 1 comprises the feeding system with the microstrip lines on the outside and a ground plane on the inside. The base portion 3 of the radiating part 2 can be either galvanically connected to the ground on the socket 1 or capacitively coupled. When it is capacitively coupled, the insulation tape 11 is included.

[0034] The foregoing descriptions are only implementation manners of the present invention, the scope of the present invention is not limited to this. Any variations or replacements can be easily made through person skilled in the art. Therefore, the protection scope of the present invention should be subject to the protection scope of the attached claims.

Claims

1. A radiating element for a base station antenna, comprising: a socket (1) and a radiating part (2),
   wherein the socket (1) has means for providing a mechanical support for the radiating part (2) and microstrip lines (5) of a feeding system for feeding the radiating part (2), and
   the radiating part (2) is configured to be received by the socket (1) and includes at least one pair of non-conductive slots (4) in a conductive element, the slots (4) being aligned to the microstrip lines (5) of the feeding system when the radiating part is received by the socket,
   and wherein an outer circumference of the socket (1) is less than a maximum outer circumference of the radiating part (2).

2. The radiating element according to claim 1, wherein the radiating part (2) comprises a base portion (3) and an extended portion, wherein the base portion (3) is pluggable to the socket (1).

3. The radiating element according to claim 2, wherein the extended portion defines the maximum outer circumference of the radiating part (2) and an outer or inner circumference of the base portion (3) is adapted to an inner or outer circumference of the socket (1) such that the base portion and the socket are in a nested configuration when the base portion (3) is received by the socket (1).

4. The radiating element according to claim 2 or 3, wherein the extended portion forms a main radiating part of the radiating element (2).

5. The radiating element according to any of claims 2 to 4, wherein each of the at least one pair of slots (4) extend in the base portion (3) and the extended portion of the radiating part (2).

6. The radiating element according to any of claims 2 to 5, wherein the socket (1) and the base portion (3) have congruent forms and, when plugged together, at least some parts of the sidewalls of the base portion (3) and the socket (1) overlap each other.

7. The radiating element according to claim 6, wherein the side walls of the socket (1) carry the microstrip lines (5) of the feeding system and the side walls of the base portions (3) include a section of the at least one pair of slots (4).

8. The radiating element according to any of the previous claims, wherein the radiating part (2) is made as a molded interconnected device, MID, with partial materialization on an inner, an outer or both sides.

9. The radiating element according to any of the claims 1 to 7, wherein the radiating part (2) is made of a solid metal part, in particular, of a stamped metal sheet.

10. The radiating element according to any of the previous claim, wherein the socket (1) carries the microstrip lines on an outer surface and the radiating part (2), in particular with reference to claim 2 the base portion (3) of the radiating part (2), is configured to be inserted into the socket (1).

11. The radiating element according to any of the previous claims, wherein the socket (1) is made as a molded interconnect device, MID.

12. The radiating element of any of the previous claims, further comprising an isolating sheet disposed between the contact surfaces of the radiating element (2) and the socket (1) at least in these areas, where the contact surfaces are conductive on opposing sides.

13. The radiating element of any of the previous claims, wherein the radiating part (2) includes means (42, 43) for fixing the radiating part to the socket (1) or to a support structure, in particular a printed circuit board, PCB (6), below the socket (1).

14. An antenna including a printed circuit board, PCB (6), the radiating element of any of the previous claims, and a radio frequency shielding cover (30), wherein the socket (1) is electrically and mechanically connected to the PCB (6), the radiating part (2) is received by the socket (1) and the radio frequency shielding (30) is provided in an area outside the outer circumference of the socket and inside the maximum outer circumference of the radiating element when projecting onto the layer of the PCB (6).

15. The antenna of claim 12, wherein the radio frequency shielding cover (30) includes an opening with a diameter larger than the socket (1) and less than the diameter of the maximum outer circumference of the radiating element.

16. A method for manufacturing an antenna element of claim 14 or 15, comprising the following steps:

mechanically and electrically connecting the socket (1) to the PCB (6);
mounting the radio frequency shielding cover (30) to the PCB (6) surrounding the socket (1); and
plugging the radiating part (2) into the socket (1) or putting the radiating part over the socket (1), at least in part, above the radio frequency shielding (30).

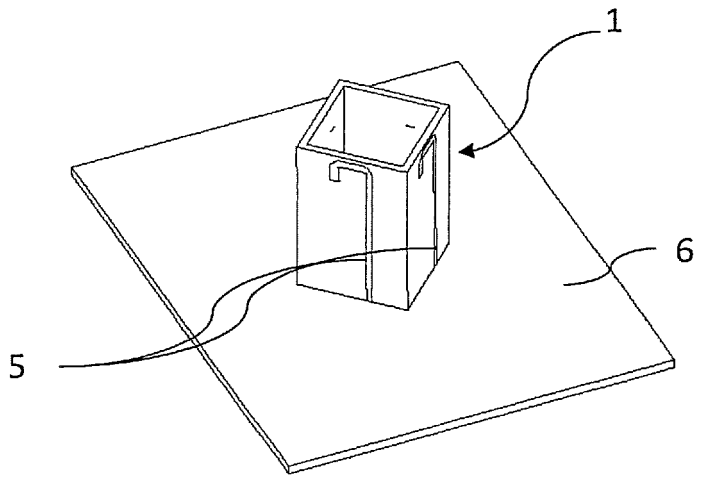


FIG. 1

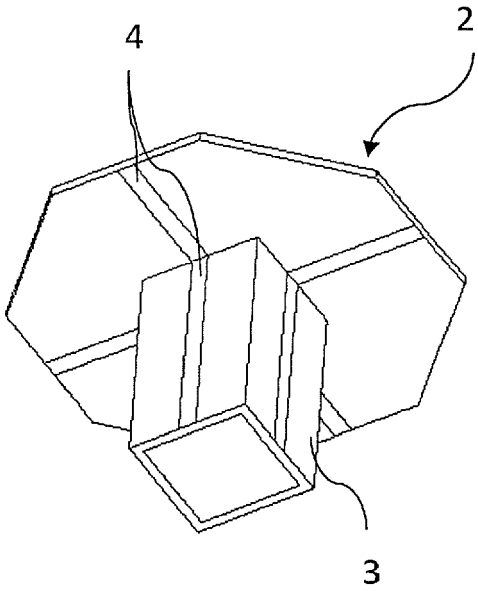


FIG. 2a

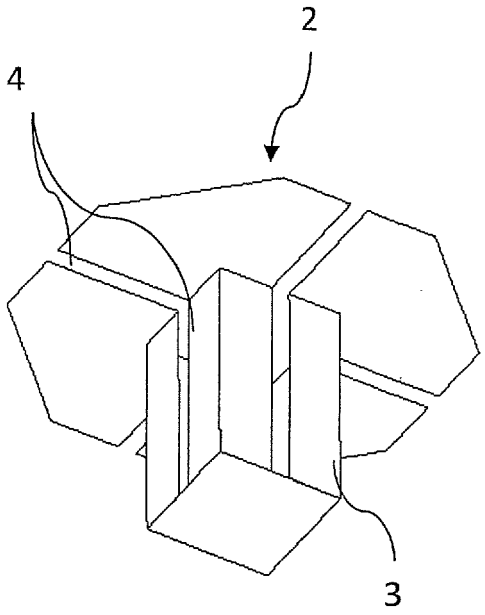


FIG. 2b

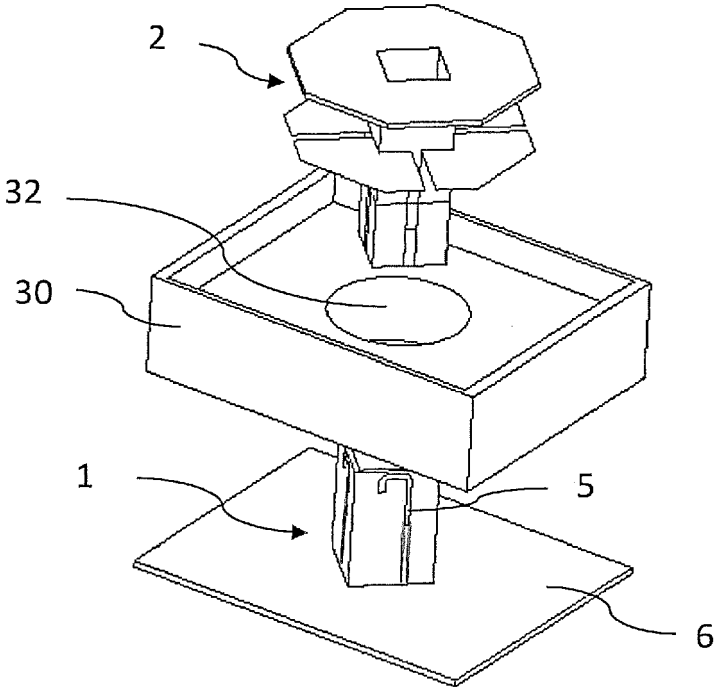


FIG. 3

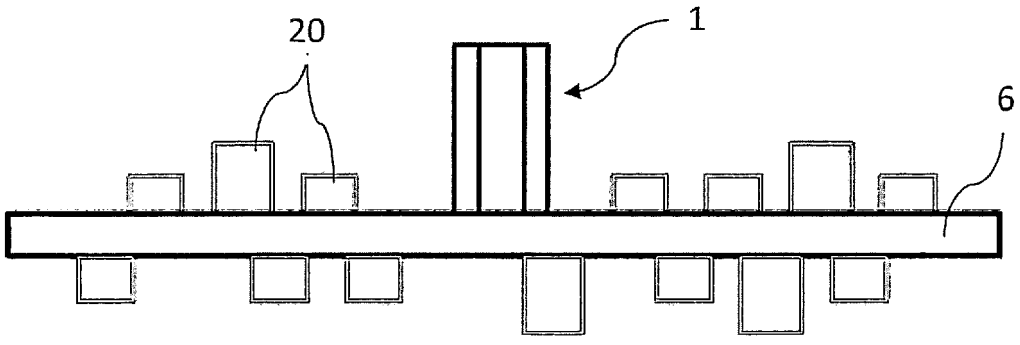


FIG. 4a

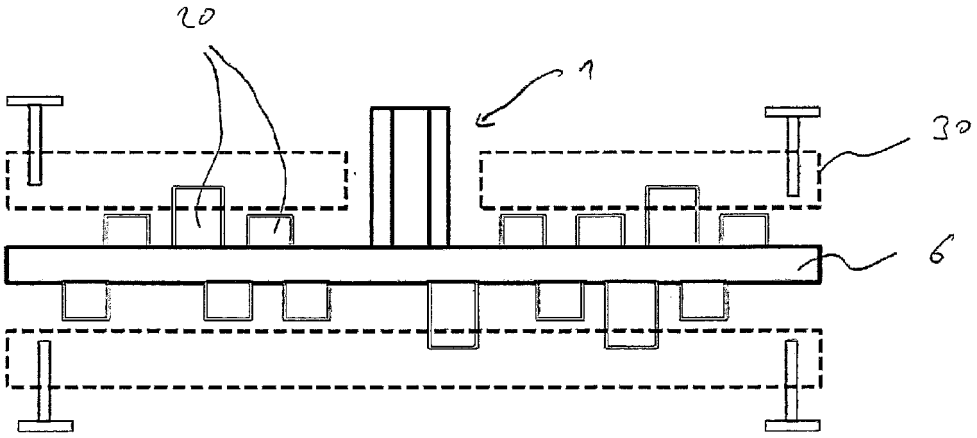


FIG. 4b

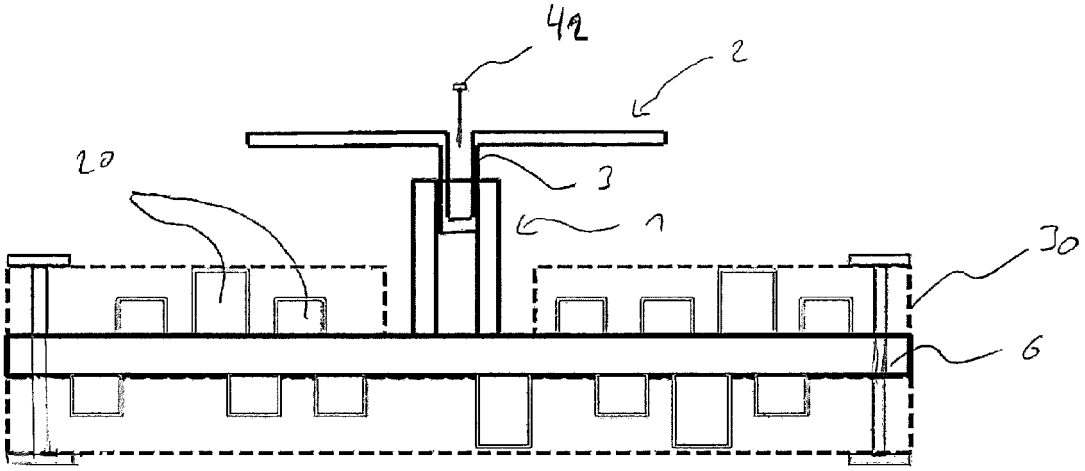


FIG. 4c

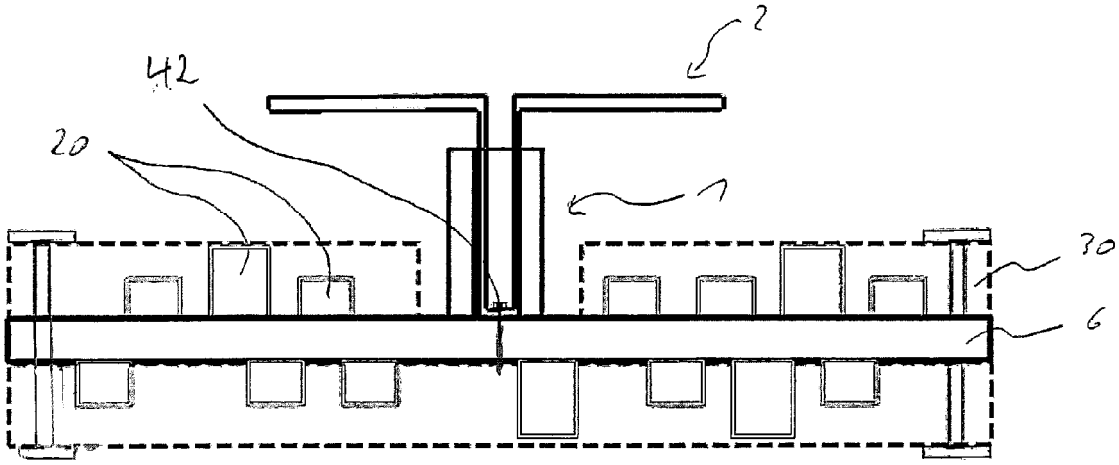


FIG. 4d

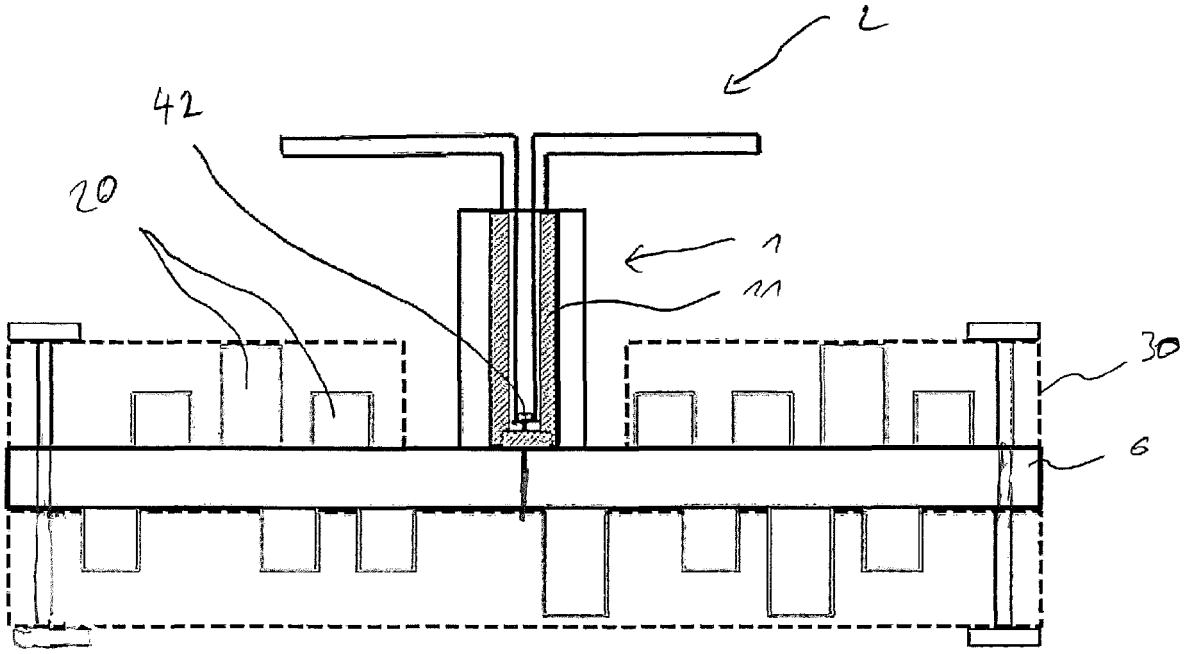


FIG. 5

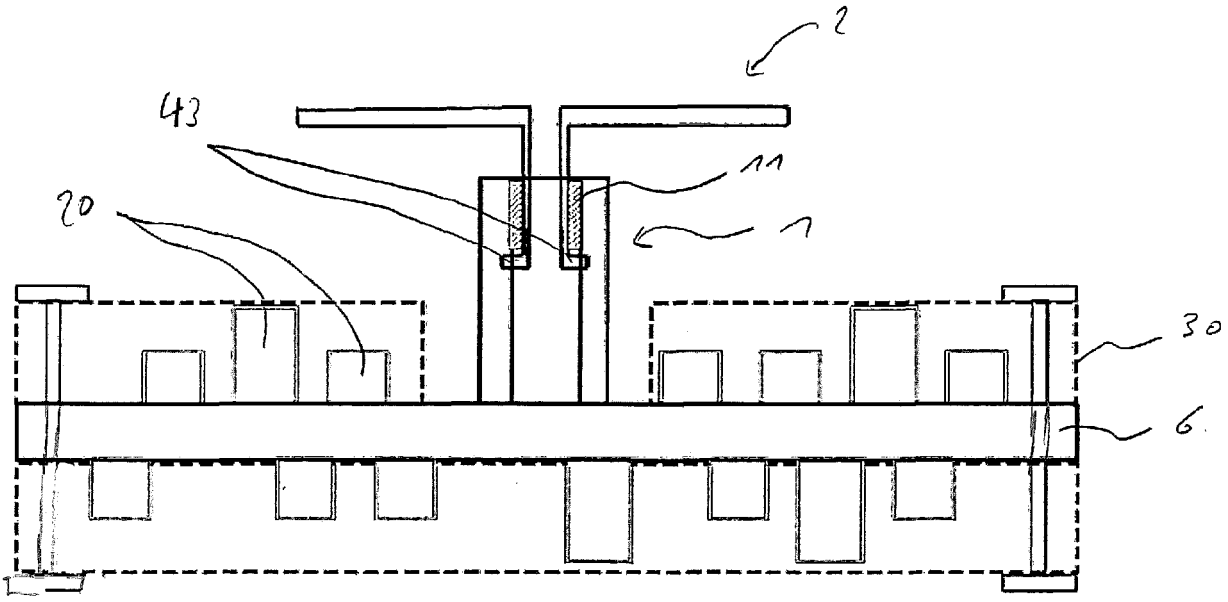


FIG. 6

Europäisches Patentamt
European Patent Office
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EUROPEAN SEARCH REPORT

Application Number
EP 16 16 6174

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	US 2014/218253 A1 (PUZELLA ANGELO M [US] ET AL) 7 August 2014 (2014-08-07) * paragraphs [0037], [0038] * * paragraphs [0049] - [0058] * * paragraphs [0061], [0065] * * paragraphs [0078], [0082] * * figures 1, 1B, 4, 4A, 5, 5A, 6, 9-9C *	1-16	INV. H01Q1/24 H01Q1/12 H01Q21/24
A	US 2004/155831 A1 (GOEBEL UHLAND [CH] ET AL) 12 August 2004 (2004-08-12) * paragraphs [0028] - [0033] * * paragraphs [0046] - [0048] * * figure 1D *	1-16	
A	US 2004/201537 A1 (STOLLE MANFRED [DE] ET AL) 14 October 2004 (2004-10-14) * paragraph [0005] * * paragraphs [0026] - [0029] * * figures 2,3,6 *	1-16	
A	WO 2005/060049 A1 (KATHREIN WERKE KG [DE]; GOETTL MAXIMILIAN [DE]) 30 June 2005 (2005-06-30) * page 17, line 9 - page 18, line 30 * * figures 7A-7E *	1-16	TECHNICAL FIELDS SEARCHED (IPC) H01Q H01P
A	WO 2016/011977 A1 (HUAWEI TECH CO LTD [CN]) 28 January 2016 (2016-01-28) * paragraphs [0034] - [0037] * * figures 6A, 6B, 7 *	1-16	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	12 October 2016	Culhaoglu, Ali

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
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