

(19) World Intellectual Property
Organization
International Bureau



(43) International Publication Date
9 September 2005 (09.09.2005)

PCT

(10) International Publication Number
WO 2005/083833 A1

(51) International Patent Classification⁷: **H01Q 1/24**,
1/48, 1/52

Barcelona (ES). **ANGUERA PROS, Jaume** [ES/ES];
Paseo Blasco Ibañez, 15-2, E-12500 Vinaros (ES).

(21) International Application Number:
PCT/EP2005/002075

(74) Agent: **CARPINTERO LOPEZ, Francisco**; Herrero &
Asociados, S.L., Alcalá, 35, E-28014 Madrid (ES).

(22) International Filing Date: 28 February 2005 (28.02.2005)

(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN,
CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI,
GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE,
KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD,
MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG,
PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SM, SY, TJ,
TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA,
ZM, ZW.

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/548,050 26 February 2004 (26.02.2004) US
60/567,615 3 May 2004 (03.05.2004) US

(71) Applicant (for all designated States except US): **FRAC-**
TUS, S.A. [ES/ES]; Alcalde Barnils, 64-68 Ed. TESTA,
Mod. C3, Parque, Empresarial Sant Joan, E-08190 Sant
Cugat del Valles (ES).

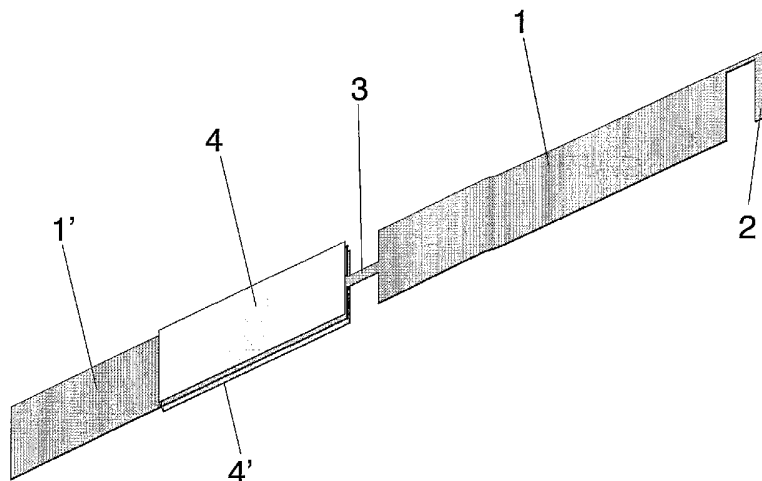
(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HU, IE, IS, IT, LT, LU, MC, NL, PL, PT, RO,
SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN,
GQ, GW, ML, MR, NE, SN, TD, TG).

(72) Inventors; and

(75) Inventors/Applicants (for US only): **PUENTE**
BALIARDA, Carles [ES/ES]; Londres 57, 4-2, E-08036

[Continued on next page]

(54) Title: HANDSET WITH ELECTROMAGNETIC BRA



(57) Abstract: The present invention relates to a handset and generally of any handheld device, which includes an antenna for receiving and transmitting electromagnetic wave signals. More in particular, the invention is related to handsets of the clamshell or flip-phone type. An electromagnetic bra structure is introduced to correct the position of the lobes of the handheld radiation pattern, so that the radiation and sensitivity of the hand held device is increased in the horizontal plane or generally to the other desired directions. The electromagnetic bra structure comprises at least one conducting surface arranged over at least one side of a ground plane of the handset, so that a resonance circuit having a high impedance at an operating frequency of the antenna is establish, to block currents and electromagnetic fields from entering a region of the ground plane.

**Declarations under Rule 4.17:**

- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii)) for all designations*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:

- *with international search report*

HANDSET WITH ELECTROMAGNETIC BRA**DESCRIPTION****5 OBJECT OF THE INVENTION**

10 The present invention relates to a handset and generally of any handheld device, which includes an antenna for receiving and transmitting electromagnetic wave signals. More in particular, the invention is related to handsets of the clamshell or flip-phone type.

15 It is an object of the present invention to provide a handset or handheld device, which incorporates means to correct the tilting and distortion of the radiation pattern lobes, so that the radiation and sensitivity of the hand held device is increased in the horizontal plane or generally to the other desired directions.

BACKGROUND OF THE INVENTION

20 The radiation pattern of a handset (and generally of any handheld device that includes an antenna for receiving and transmitting electromagnetic wave signals) is determined, among other factors, by the antenna shape, its position on the handset, and also the handset size and its physical construction. Usually, the antenna is placed at an edge of the handset to maximize
25 radiation. Such an edge is usually the top part of the handset (near the earphone) although can also be in some cases the bottom part (near the speaker). This way, the combination of such a position together with the size of the handset, and in particular the size of the grounding metals inside the handset (mainly printed circuit boards and electromagnetic shields), usually
30 determine the shape of the pattern.

The example shown in figure 1 describes this fact. Figure 1 is a simplified model of a handset, including a printed circuit board (PCB) for the conducting ground (1) (wider rectangle on the left), and a whip antenna (2) (narrow strip on the right) which is typically a quarter of a wavelength in length.

5

Typical radiation patterns for such a handset are shown in figure 2. Such a pattern shows a vertical cut (XZ plane) on the handset, with the top part (antenna) placed on the right side of the horizontal X axis, and the handset body on the left side of same axis.

10

It is seen on such a plot that typically the radiation pattern is tilted towards the lower part of the handset. That is, radiation is enhanced below horizon (vertical axis on the graph) which is an inconvenience when receiving and transmitting from long distance base stations, since in these cases radiation comes from the vicinity of a horizontal plane (ZY plane). This phenomenon is related to the distribution of currents flowing on the handset, which are asymmetrically split between the antenna and the casing (PCB, shieldings) of the phone. Again, the antenna position, together with the PCB and handset size, are the determining effects contributing to this phenomenon.

15

20

This problem becomes even more relevant when the handset is of the clamshell or flip-phone type. In clamshell phones, the keyboard and screen are usually split in two parts that unfold apart by means of a hinge connecting said two parts. Both parts of the phone include metal parts (PCB, shieldings) and are interconnected by means of a flexible circuit or wire set. When such a type of handheld is unfolded, the overall length of the metal part (typically the PCB ground) is increased, which again influences the shape of the radiation pattern. This example of a handset and pattern distortion effect is shown in figures 3, 4 and 5.

25

30

Figure 4 shows a typical difference between the folded and unfolded phone radiation patterns in the horizontal plane (YZ). The unfolded phone radiates (and receives) a weaker signal (smaller circle) in the horizontal plane than the folded one. This is due to a pattern distortion in the vertical plane (XZ) as shown in figure 5. The new pattern displays a minimum radiation on the horizontal plane, while steering radiation to other for quadrants in space. This effect can be even more significant when a handset integrates a small internal antenna.

Some structures known in the prior art, such as multilevel structures, space-filling curves or the ground planes described in the PCT publication WO03023900, can be advantageously used in the present invention.

The PCT publication WO0122528 describes a multilevel structure for an antenna device consisting of a conducting structure including a set of polygons, all of said polygons featuring the same number of sides, wherein said polygons are electromagnetically coupled either by means of a capacitive coupling or ohmic contact, wherein the contact region between directly connected polygons is narrower than 50% of the perimeter of said polygons in at least 75% of said polygons defining said conducting multilevel structure. In this definition of multilevel structures, circles and ellipses are included as well, since they can be understood as polygons with a very large (ideally infinite) number of sides.

The PCT publication WO0154225 describes a space-filling curve SFC: as a curve composed by at least ten segments which are connected in such a way that each segment forms an angle with their neighbours, that is, no pair of adjacent segments define a larger straight segment, and wherein the curve can be optionally periodic along a fixed straight direction of space if, and only if, the period is defined by a non-periodic curve composed by at least ten connected segments and no pair of said adjacent and connected segments

defines a straight longer segment. Also, whatever the design of such SFC is, it can never intersect with itself at any point except the initial and final point (that is, the whole curve can be arranged as a closed curve or loop, but none of the parts of the curve can become a closed loop). A space-filling curve can be fitted over a flat or curved surface, and due to the angles between segments, the physical length of the curve is always larger than that of any straight line that can be fitted in the same area (surface) as said space-filling curve. Additionally, to properly shape the gap according to the present invention, the segments of the SFC curves included in said multilevel structure must be shorter than a tenth of the free-space operating wavelength.

The PCT publication WO03023900 describes a ground-plane for an antenna device, comprising at least two conducting surfaces, said conducting surfaces being connected by at least a conducting strip, said strip being narrower than the width of any of said two conducting surfaces.

SUMMARY OF THE INVENTION

The present invention provides means to correct such a tilting and distortion of the radiation pattern lobes, such as radiation and sensitivity of the handheld device is increased in the horizontal plane, or generally to other desired directions. An electromagnetic bra structure (EBS) is introduced in the present invention to correct the position of the lobes of the handheld radiation pattern.

A first aspect of the present invention refers to a handset for radio communication, which comprises an antenna and a ground-plane associated with the antenna, the antenna being situated in correspondence with an antenna end of the ground-plane. Said handset is characterised in that it comprises an electromagnetic bra structure which comprises at least one conducting surface situated over a part of the ground-plane and separated

from said part of the ground-plane. Said at least one conducting surface is arranged so that said part of the ground-plane and said at least one conducting surface, in combination, establish a resonance circuit having a high impedance at an operating frequency of the antenna, towards the antenna end of the ground plane.

Due to this high impedance, operating frequency currents are substantially prevented from flowing into said part of the ground-plane, whereby said part of the ground-plane is prevented from influencing the radiation pattern. This provides for a virtually shorter ground-plane from the electromagnetic point of view, as part of the entire physical ground-plane will be functionally "disconnected" at the operating frequency. Consequently, the pattern shape is changed in the desired direction and a dramatic increase in the radiation, for example in the horizontal plane, is obtained.

Said conducting surface may be short-circuited to the ground-plane at a position situated at a distance from an end of the conducting surface facing the antenna end of the ground-plane, said distance being such that it corresponds to an electric path length of substantially one quarter of the wavelength at the operating frequency, or an odd multiple of a quarter of said wave length. Said short circuit can comprise an actual direct (galvanic) electrical connection or a virtual short-circuit providing a low impedance path between the ground-plane and the conducting surface at the operating frequency.

Optionally, said at least one conducting surface is not short-circuited to the ground-plane, and said at least one conducting surface is arranged such that said resonance circuit has a first open end facing the antenna end of the ground-plane, and a second open end separated from said first open end, by a distance corresponding to an electrical path length substantially equal to

half of the wavelength, or a multiple of said half of the wavelength, at the operating frequency.

5 It should be stressed that such an EBS should not be confused with a conventional EMI shield, which completely encases a part of a circuit inside an electromagnetic cage. Such a conventional shielding, instead of blocking currents and electromagnetic fields, would conduct currents on top of its surface not raising (pushing-up) properly the lobes as in the case of the Electromagnetic Bra Structure. In the EBS, due to the high impedance
10 resonance circuit established by said at least one conducting surface in cooperation with the ground plane, electric currents and electromagnetic fields are blocked from entering the region of the ground plane covered by said at least one conducting surface.

15 Another aspect of the invention refers to a method of producing the above-described handset for radio communication. The method comprises the step of arranging at least one conducting surface over a part of the ground-plane and separated from said part of the ground-plane, so that said part of the ground-plane and said at least one conducting surface, in combination,
20 establish a resonance circuit having a high impedance at an operating frequency of the antenna, towards the antenna end of the ground plane.

BRIEF DESCRIPTION OF THE DRAWINGS

25 To complete the description and in order to provide for a better understanding of the invention, a set of drawings is provided. Said drawings form an integral part of the description and illustrate a preferred embodiment of the invention, which should not be interpreted as restricting the scope of the invention, but just as an example of how the invention can be embodied.

30 The drawings comprise the following figures:

Figure 1.- shows a simplified model of a prior-art handset including an antenna (narrow strip on the right). X and Y axes are shown for reference.

Figure 2.- shows a vertical cut (XZ plane) of a typical radiation pattern of a handset structure as per that on figure 1.

Figure 3.- shows an unfolded model of a prior-art clamshell phone. The unfolded phone forms a longer electromagnetic ground plane for the antenna.

Figure 4.- shows a horizontal cut of the radiation pattern of a folded (figure 4a) and unfolded (figure 4b) clamshell phone.

Figure 5.- shows a vertical cut of the radiation pattern of a folded (figure 5a) and unfolded (figure 5b) clamshell phone.

Figure 6.- shows a top view of an unfolded phone with internal L-shaped antenna and with an EBS at the opposite side.

Figure 7.- shows a perspective view of a lower portion of the handheld model in figure 6.

Figure 8.- shows in figure 8a a side elevational view of the unfolded phone of figures 6, and in figure 8b a side elevational view of the unfolded phone of figure 10.

Figure 9.- shows examples of the differences in radiation that can be obtained by using an EBS. Conventional structure features radiation patterns on the left side (figures 9a, 9c), while patterns of handset including EBS are shown on the right (figures 9b, 9d).

Figure 10.- shows a perspective view of a handset with EBS placed in a middle region of the lower part of the ground plane. Open edge of EBS is placed by the strip interconnecting both parts of the ground plane, such the whole lower half of the handset becomes effectively disconnected.

5

Figure 11.- shows the increase of radiation (figure 11b) of the EBS in figure 10, compared with a conventional handset with no EBS (figure 11a).

10

Figure 12.- shows top views of several forms of EBS. From top to down: figure 12a array of parallel strips with ground plane and open edge towards the ground plane interconnection; figure 12b two parallel strip EBS at the edges of the ground plan; figure 11c single strip EBS; figure 11d rib-like EBS with strips perpendicular to the central axis of the handset, figure 11e similar embodiment as in figure 11a but with strips of different length.

15

Figure 13.- shows in figure 13a a top view of an EBS structure made of two parallel stubs interconnected at one open end. Said open end is facing the interconnection between the two PCBs. The strips can be made a quarter-wavelength with a short at one end (figure 13a), or half a wavelength with both ends in open circuit (figure 13b).

20

DESCRIPTION OF THE PREFERRED EMBODIMENT OF THE INVENTION

One preferred embodiment of an electromagnetic bra structure EBS, is shown in figure 6 and figure 7. Figure 6 shows an unfolded clamshell phone with an L-shaped internal antenna (2) on the right side. The skilled in the art will notice that the following technique can be used with any other kind of antenna. For instance it can be combined with whip, PIFA, IFA, multilevel, space-filling, fractal, meander and other kind of antennas.

30

In the embodiment shown figures 6 and 7, it can be observed the antenna (2) and the ground plane (1) comprising a first conducting part (1') and a second conducting part (1''), said first and second conducting parts being electrically connected by at least a conducting strip (3), said strip being narrower than the width of any of said first and second conducting parts (1',1''). The Electromagnetic Bra Structure in this particular embodiment, is formed by a first conducting surface (4) placed over one side of the first conducting part (1') of the ground plane, and a second conducting surface (4'') placed over the other side of the first conducting part (1') of the ground plane.

The conducting surfaces (4,4'') in this particular embodiment, are defined by a substantially rectangular conducting plate, and the first and second parts (1',1'') of the ground plane (1) are also substantially rectangular. The conducting surfaces (4,4'') are short-circuited respectively at one of their ends to the ground plane (1') by means of a first conducting plate (5) and a second conducting plate (5'), thereby the EBS (4,4',5,5') is formed by two L-shaped plates at both sides of the ground plane (1), said plates being electrically connected (shorted) to said ground plane nearby the bottom edge of the phone. Preferably, the conducting surfaces (4,4') on each side of the ground plane are a mirror image of each other.

In the embodiment represented in figures 6, 7 and 8, the first conducting part (1') and a second conducting part (1'') of the ground plane, and the conducting strip (3) are aligned along a longitudinal axis (x). The conducting surfaces (4,4') are also substantially rectangular and have the same width of the ground plane (1), and the short-circuited end (6) is placed right over the lower edge (8) of the first conducting part (1') and it is connected thereto, whereas the open end (7) is facing the conducting strip (3).

Typically, as indicated in figure 8, the length of the conducting plate defining the conducting surfaces (4,4') (longer arm of the L shape) is about (+/- 20%) of a quarter of the wavelength from the short end (6) to the open end (7). Such a structure, that is the conducting surface arranged in cooperation over
5 a part of the ground-plane, establish a resonance circuit having a high impedance at an operating frequency of the antenna, which blocks currents and electromagnetic fields from entering the region of the ground plane between the two surfaces (4,4'). That arrangement makes the whole set shorter from the electromagnetic point of view.

This effect is shown, without any limiting purpose, in the radiation patterns of figure 9. Original radiation pattern of handset with internal antenna without EBS is shown on figures 9a and 9c (horizontal YZ cuts on figure 9a, vertical
10 XZ cuts on figure 9c), while the patterns with the handset including such an EBS structure is shown on figures 9b, 9d. Clearly, a local maximum of radiation is obtained in the horizontal plane where a minimum used to be before. This is observed in both cuts of the radiation pattern.

The pattern shaped can be changed for instance by modifying the shape of the EBS, its position on the ground plane or both. Therefore the conducting
20 surfaces (4,4') may have any shape, and they can be defined by an outer perimeter comprising at least one straight segment and/or at least one curved line. Similarly, the ground plane (1) may adopt any shape, and it can be also defined by an outer perimeter comprising at least one straight segment and/or
25 at least a curved line.

Figure 10 shows another embodiment where the EBS (4,4',5,5') is placed upper over the first conducting part (1') of the ground plane, so that the short-circuited ends (6,6') is connected to an inner part of said first
30 conducting part (1'). The open ends (7,7') of the two plates defining the conducting surfaces (4,4') is placed just by the top of the first conducting part

(1'), nearby its connection point (9) with the conducting strip (3), as shown in figure 8b. This way, the first conducting part (1') becomes effectively disconnected from the radiation point of view, and the pattern shape is changed again accordingly. Again, a dramatic increase on the radiation nearby the horizontal plane is observed, as shown in figure 11b with respect to the radiation pattern of figure 11a corresponding to a conventional handset with no EBS.

In the embodiments of figures 6 and 10 at least one edge of one conducting surface (4,4') and at least one edge of the ground plane (1), are lying on a plane which is substantially perpendicular to the ground plane (1).

There are many ways the EBS can be put into practice within the scope and spirit of the invention. Generally any kind of conducting structure of the proper length (about a quarter wavelength or an odd multiple of a quarter wavelength) including a shorting means can be used. For instance, and without any limiting purpose, an EBS is formed by two stamped L-shaped conducting plates which are connected to the ground PCB at their shorted edge. Any conducting material such as copper, brass, tin or lead could be for instance applied to build the plates. Also, such plates could be made of a plastic covered or melted with a layer of conducting material, such as a conducting electromagnetic interference (EMI) blocking paint or similar. The EBS requires a part of the structure being grounded, a part of it being in open circuit, and the distance between such a short or ground being around one quarter wavelength to resonate in a high-impedance mode.

A particular way of implementing the EBS is by using two layers on a multilayer Printed Circuit Board (PCB). Two conducting plates defining the conducting surfaces (4,4'), are printed on two layers including the ground plane (1) in between, such a two plates being connected to ground by means

of any grounding technique, such as for instance metallized via holes on the multilayer substrates.

5 The EBS can be placed at one or both sides of the ground plane. Although generally a two-sided configuration is preferred, in some cases where there are some mechanical constraints that make such a configuration difficult, a single-sided solution is also possible, by placing the EBS structure or a part of it on the side of the ground plane (1) with more significant contribution on the radiation pattern.

10 Also, the shape of such an EBS does not necessarily need to be planar and rectangular. In general, any shape can be taken, as long as one region of the EBS conductor is shorted to ground and the rest of it is left open towards the region where propagating electromagnetic waves and currents are to be
15 blocked. The conducting surface structure for the EBS can be made conformal to any other part of the handset. For instance, in another preferred embodiment, the EBS is made by coating the internal plastic cases of a handset (front and back covers) with a layer of conducting paint or ink, such as for instance an EMI blocking material, said coating being grounded for
20 instance by means of a conductive paste or ink reaching a metal pad or ground region on the ground plane (1).

25 Therefore, the conducting surfaces (4,4') of the EBS are lying on a planar or curved surface, or in other embodiments some areas of the conducting surfaces may be planar and other parts can be curved areas to conform a particular part of the handset. The planar parts of the conducting surfaces (4,4'), are preferably substantially parallel to the ground plane (1).

30 The conducting surfaces (4,4') are placed at a suitable distance from the ground plane. In the present invention one preferred value for said distance, is any value within the range 0.8 millimetres to 2 centimetres.

It will be seen that the short circuit (5,5') does not necessarily need to be a physical short on the metal piece. A virtual RF short, i.e. a very low impedance element at RF frequencies are possible as well. For instance, a high capacitance components or capacitive structures can be used to implement the short to ground.

In another preferred embodiment of the invention, it is possible to replace the short by a second quarter-wavelength section (or an odd multiple of a quarter wavelength) with a first end connected at the point where the virtual short is required, said second section featuring also an open circuit at a second end. This way, the combination of the quarter wavelength size and the open circuit at the second end, provides the required RF short at said first end.

The EBS does not necessarily need to be a completely solid metallic structure. For some manufacturing, cost or weight reasons, several clearances on the plates defining the conducting surfaces can be included. These can take the form of holes on the EBS plates, or uncoated regions on the handset back cover, or alike when the conducting surfaces are implemented by means of a layer of a conducting paste, paint or ink. For instance, the EBS can be implemented with a mesh or grid of wires or strips.

Another way of implementing an EBS is by using an array of strips (10), with one end (12) of the strip connected to the ground plane (1), and the opposite end (12) being left in open circuit. These strips (10) are narrower than the ground plane and can be arranged parallel or perpendicular to a handset vertical axis (x) in a rib-like structure. In the case of clamshell phones, where current mainly flows from a conducting part of the ground plane to the other through flexible interconnecting strips (3), a single narrower strip (10), as shown in figure 12c, can be used to block or partially block, at least a part of the current and waves flowing from one conducting part of the ground plane to the other as well. In this case, the open end (12) of the strip (10) will be

preferably placed in the area around the interconnection between the two conducting parts (1',1'') of the ground plane. In the embodiment of figure 12c, the conducting strip (10), aligned with the conducting strip (3), has approximately the same width of the conducting strip (3), and it is electrically connected to an inner part of the first conducting part (1') of the ground plane (1). In the other embodiments of figure 12, the strips (10) are short-circuited to one edge of the ground plane by means of an electrical connection (11).

In those cases where main of the current propagates along the edge of the ground plane, a single strip or several strips (10) at both edges of the ground plane can be placed as well, as shown in the embodiment of figure 12b. Also, when the radiation pattern lobes are to be raised or modified at several frequencies, several strips (10) of several lengths can be used as shown in the embodiment of figure 12e, or even a single wide plate with a conformal contour.

Stacking and nesting several EBS for several frequencies (with several lengths) is also possible within the scope and spirit of the present invention, that is several strips (10) of different length, can be stacked in planes separated at different distances from the ground plane.

Again, the RF short does not need to be a physical short to ground, it can be provided by a high capacitance structure or component such as a capacitor, a metal plate close to ground or a resonant transmission line or stub. For instance, another quarter-wavelength strip with one open end will introduce an effective short at the opposite end. This can be advantageous in those devices where, for any reason it is mechanically or industrially difficult or costly to provide a physical short to ground. In those cases, the quarter wavelength EBS structure might be replaced by a half-wavelength structure

(or an entire multiple of a half-wavelength structure) with two opens at both ends.

5 In some devices where there exists a ground plane (1) formed by a first and a second conducting part (1',1''), with an electrical interconnection (3) between them, it is advantageous to block the currents flowing from one part of the ground plane to the other just at the interconnection point or points. This can be achieved for instance by placing a strip or transmission line with an open end facing said interconnection. Other equivalent means such as
10 two-parallel quarterwavelength structures connected at the open end is also possible. This is shown in figure 13a which displays a 'U' shaped structure, each arm (13,13') of the U featuring about a quarter wavelength and a short (11) to the ground plane (1) at one end of each arm (13,13'). Both arms (13,13') are connected together to a common strip which forms an extension
15 (14) that faces the interconnection (3) between the two parts (1',1'') of the ground plane, which effectively provides an open circuit that stops currents flowing from one part of the ground plane to the other.

20 Again, as it is shown in figure 13b, quarter wavelength structures can be replaced by half-wavelength structures with two open ends instead of an open end and a shorted end. In the embodiment of figure 13b the conducting strip (10) is formed by two side arms (15,15') connected by a common arm (16) which is provided with an extension (14) facing the conducting strip (3).

25 The rib-like structure in figure 12 effectively introduces a periodic or quasi-periodic structure in the direction of propagation of waves from top to down. Periodic and quasi-periodic structures can be used to modify the propagation characteristics of electromagnetic waves. In particular, they can be used to block and reject waves within a range of frequencies. Periodic structures are
30 used in electromagnetic devices in the form of photonic or electromagnetic

band-gap structures (PBG or EBG), frequency selective surfaces (FSS), and metamaterials.

Periodic structures can be used also to implement an EBS in a handheld device. A periodic arrangement of conducting or dielectric patterns, connected or not to the PCB ground or other ground of the handset is used also to make an effective EBS. Such a periodic EBS (PEBS) can be implemented, for instance, by coating a region on the front and/or back cover of the handset with a set of strips or other conducting patterns, such as for instance a tile of polygons, a tile of space-filling or multilevel shapes (see for instance patent publication WO0122528 and WO0154225 for multilevel and space-filling structures), fractal or meander shapes. Therefore, in some embodiments a part of at least one conducting surface and/or a part of the ground plane is a multilevel structure or a space-filling curve.

Another PEBS is built by shaping at least a portion of the ground-plane on the PCB with such a periodic set of slots or gaps. These slots take the form of for instance narrow strips, space-filling, multilevel, fractal or meander shapes.

An embodiment for a PEBS is made by tiling at least one layer of a multilayer PCB of the handset with a set of shaped conductive pads (said patterns being for instance polygonal, multilevel or space-filling). These pads are optionally connected to ground, for instance by means of one or several conducting via-holes. Also, such a tile of shaped pads can be arranged at both sides of the PCB ground, or even in multiple layers at both sides of the ground, to arrange a single-frequency or multiple-frequency PEBS.

Another construction of an EBS consists on a conformal arrangement of a shape or set of shapes on the ground-plane on at least one of the PCBs of

the handset. Such a construction can take the form of for instance a structure as described in the PCT publication WO03023900.

5 In the embodiments of figures 12 and 13 only one side of the ground plane (1) is shown. Preferably, the other side of the ground plane (1), comprises also conducting surfaces (4,4') defined by strips (10) which are a mirror image of the strips (10) shown on said figures 12 and 13.

10 Further embodiments of the invention are described in the dependent claims.

The invention is obviously not limited to the specific embodiment(s) described herein, but also encompasses any variations that may be considered by any person skilled in the art (for example, as regards the choice of materials, dimensions, components, configuration, etc.), within the
15 general scope of the invention as defined in the claims.

CLAIMS

1.- Handset for radio communication, comprising an antenna and a ground-plane associated with the antenna, the antenna being situated in correspondence with an antenna end of the ground-plane, **characterised** in that it further comprises at least one conducting surface situated over a part of the ground-plane and separated from said part of the ground-plane, said at least one conducting surface being arranged so that said part of the ground-plane and said at least one conducting surface, in combination, establish a resonance circuit having a high impedance at an operating frequency of the antenna, towards the antenna end of the ground plane.

2.-Handset according to claim 1, wherein said at least one conducting surface is short-circuited to the ground-plane at a position situated at a distance from an end of the conducting surface facing the antenna end of the ground-plane, said distance being such that it corresponds to an electric path length of substantially one quarter of the wavelength at the operating frequency, or an odd multiple of a quarter of said wave length.

3.- Handset according to claim 1, wherein said at least one conducting surface is not short-circuited to the ground-plane, said at least one conducting surface being arranged such that said resonance circuit has a first open end facing the antenna end of the ground-plane and a second open end separated from said first open end by a distance corresponding to an electrical path length substantially equal to half of the wavelength or a multiple of said half of the wavelength, at the operating frequency.

4.- Handset according to claim 1 or 2 wherein the ground plane defines an outer perimeter and wherein said at least one conducting surface is short-circuited to the perimeter of the ground plane or to an inner part of the ground plane.

5.- Handset according to any of the preceding claims wherein it comprises at least one conducting surface over each side of said ground plane.

5 6.- Handset according to any of the preceding claims wherein said at least one conducting surface is defined by a conducting plate or by a layer of conducting material selected from the group comprising: conducting paint, conducting ink or conducting paste.

10 7.- Handset according to any of the preceding claims wherein at least one edge of one conducting surface and at least one edge of the ground plane, are lying on a plane which is substantially perpendicular to the ground plane.

15 8.- Handset according to any of the preceding claims wherein at least one part of said at least one conducting surface is substantially parallel to the ground plane.

20 9.- Handset according to any of the preceding claims wherein the ground plane comprises a first conducting part and a second conducting part, said first and second conducting parts being electrically connected by at least a conducting strip, said strip being narrower than the width of any of said first and second conducting parts.

25 10.- Handset according to claim 9 wherein the first and the second part of the ground plane are substantially rectangular.

 11.- Handset according to any of the preceding claims wherein said at least one conducting surface is substantially rectangular.

30

12.- Handset according to claim 10 or 11 wherein said at least one conducting surface has the same width as the first or the second part of the ground plane.

5 13.- Handset according to claim 10 or 11 wherein said at least one conducting surface is narrower than the ground plane.

14.- Handset according to any of the claims 11 to 13 wherein said at least one conducting surface is aligned with said conducting strip.

10

15.- Handset according to any of the claims 9 to 14 wherein said at least one conducting surface comprises a first end short-circuited to the ground plane, and a second end which is an open circuit and it is facing said conducting strip.

15

16.- Handset according to any of the preceding claims wherein comprises an array of two or more conducting surfaces narrower than the ground plane, said conducting surfaces arranged parallel or perpendicular with respect to a ground plane longitudinal axis.

20

17.- Handset according to claim 16 wherein the conducting surfaces have different length and/or different width.

25

18.- Handset according to claim 16 or 17 wherein the array of conducting surfaces is a periodic structure.

30

19.- Handset according to any of the claims 1,2, 4 to 18 wherein said at least one conducting surface is U-shaped having two side arms wherein each side arm features an electrical length of substantially a quarter wavelength at the operating frequency, and wherein said side arms are short-circuited at their ends to the ground plane, and wherein said at least

one conducting surface comprises an extension which is facing said conducting strip.

20.- Handset according to any of the claims 1,3, 4 to 18 wherein said at least one conducting surface comprises two side arms having each arm an end in open circuit, and wherein each arms features an electrical length of substantially half of wavelength at the operating frequency, and wherein said at least one conducting surface comprises an extension which is facing said conducting strip.

21.- Handset according to any of the preceding claims wherein the conducting surfaces and/or the ground plane are a conducting layer of a multilayer printed circuit board, and wherein the ground plane layer is located in between said conducting surfaces.

22.- Handset according to claim 21 wherein said at least one conducting surface is short-circuited to the ground plane by means of a metallized via hole in the printed circuit board.

23.- Handset according to any of the claims 5 to 22 wherein at least one conducting surface over one side of the ground plane, is a mirror image of another conducting surface placed over the other side of the ground plane.

24.- Handset according to any of the claims 6 to 23 wherein the handset comprises a cover made of non-conducting material and wherein said conducting paint, paste or ink is coated on a face of said cover.

25.- Handset according to any of the claims 2, 4 to 20, 21 to 24 wherein said at least one conducting surface is short-circuited to the ground plane by means of shorting means selected from the group comprising: a metallic

connection, a capacitive component having low impedance at RF frequencies, conductive paint, conductive paste or conductive ink

5 26.- Handset according to any of the preceding claims wherein it is a clamshell or flip-phone handset.

10 27.- Handset according to any of the preceding claims wherein a part of at least one conducting surface and/or a part of the ground plane is a multilevel structure or a space-filling curve.

15 28.- A clamshell handset including an electromagnetic bra structure at least at one half of the handset phone, such an electromagnetic bra structure comprising two conducting plates, said plates being placed at both sides of a ground plane of such a handset, both of said plates being connected at least at one point of the handset, said plates being a quarter wave in length or an odd multiple of a quarter wavelength, with the opening nearby the hinge of said clamshell phone.

20 29.- Method of producing a handset according to any of the preceding claims characterised in that it comprises arranging at least one conducting surface over a part of the ground-plane and separated from said part of the ground-plane, so that said part of the ground-plane and said at least one conducting surface, in combination, establish a resonance circuit having a high impedance at an operating frequency of the antenna, towards the
25 antenna end of the ground plane.

1/12

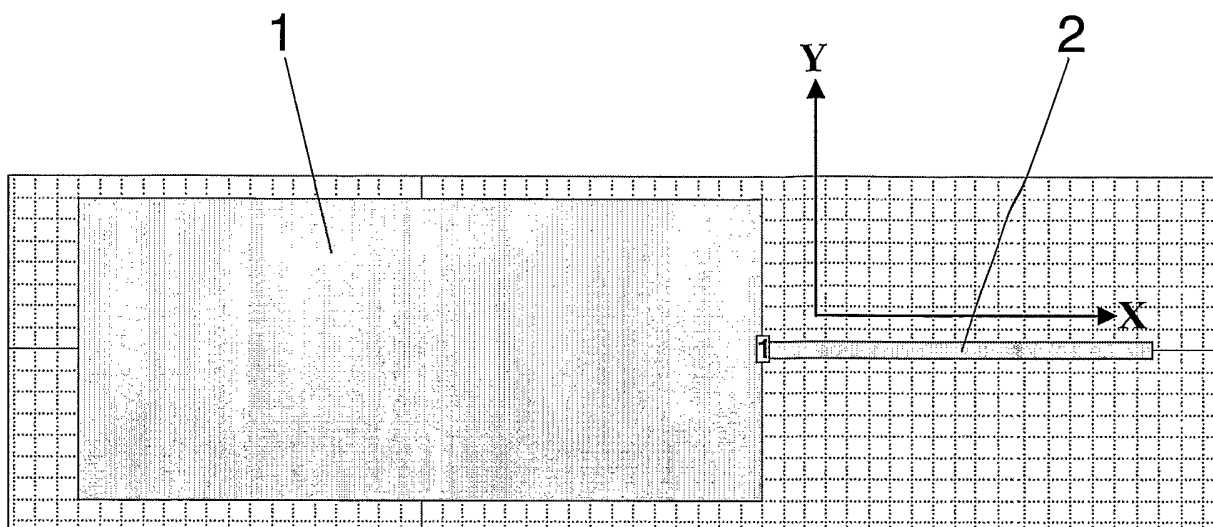


FIG. 1
(PRIOR-ART)

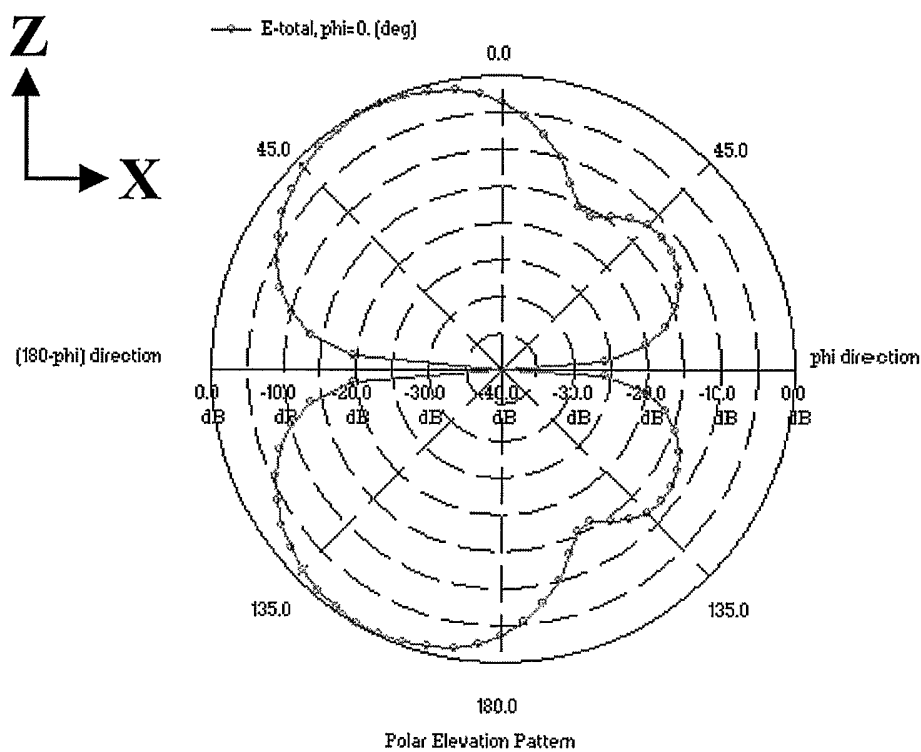


FIG. 2
(PRIOR-ART)

2/12

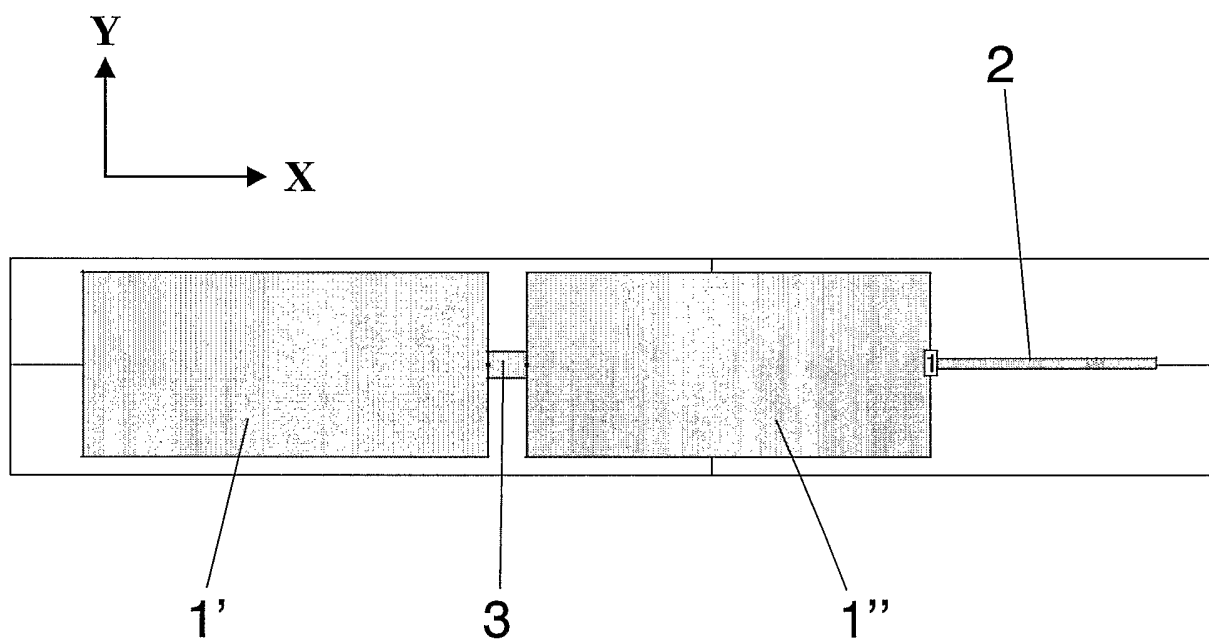


FIG. 3
(PRIOR-ART)

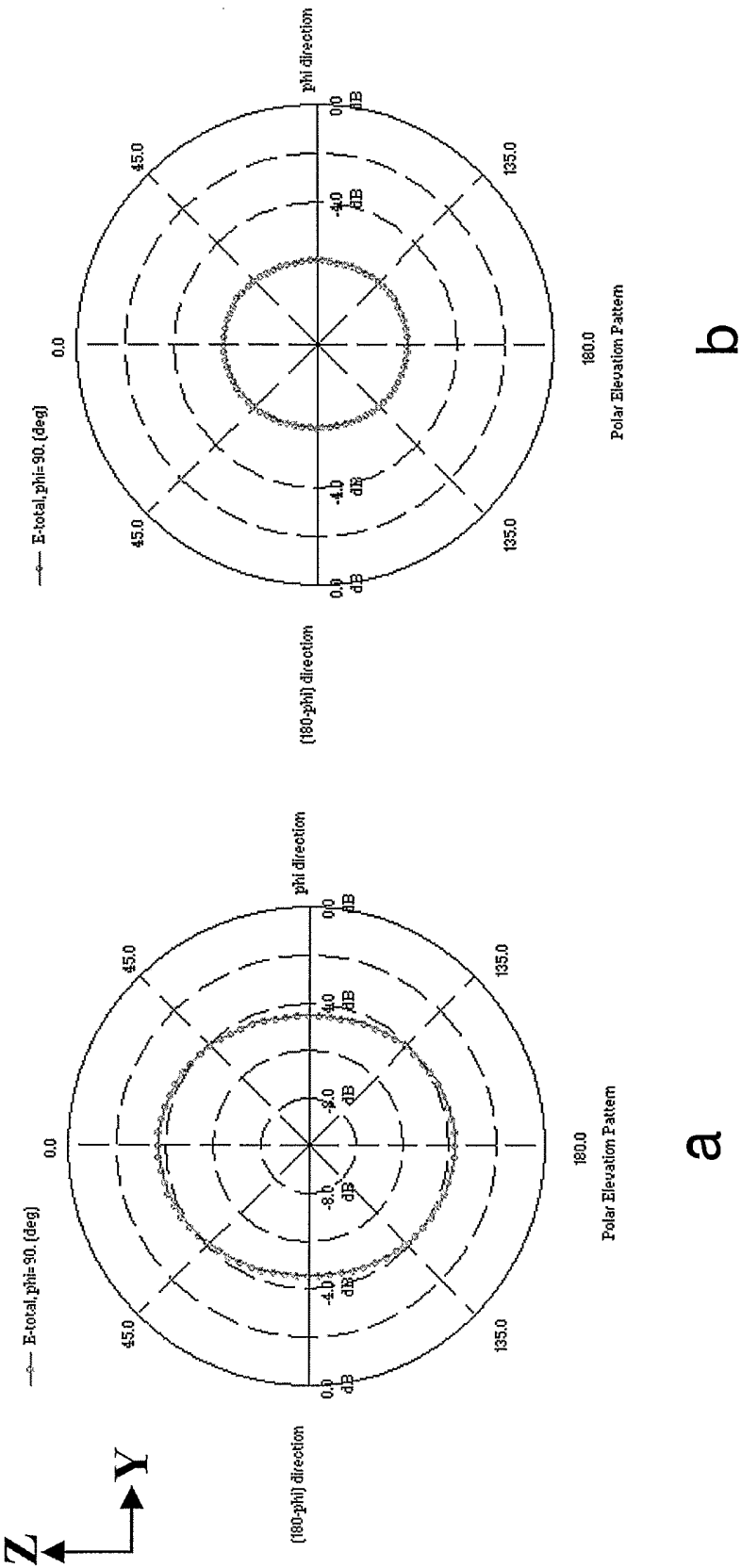
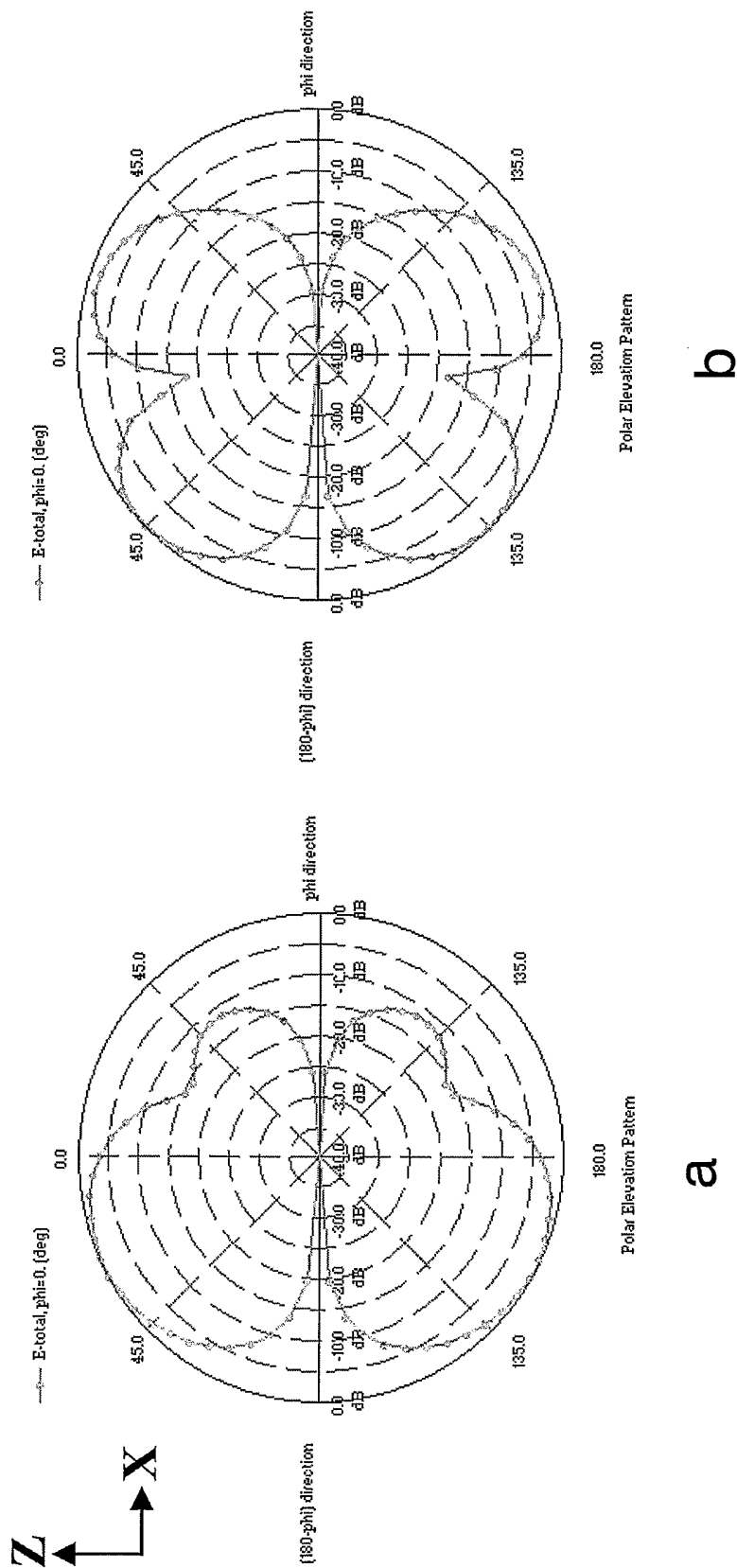


FIG. 4
(PRIOR-ART)



5/12

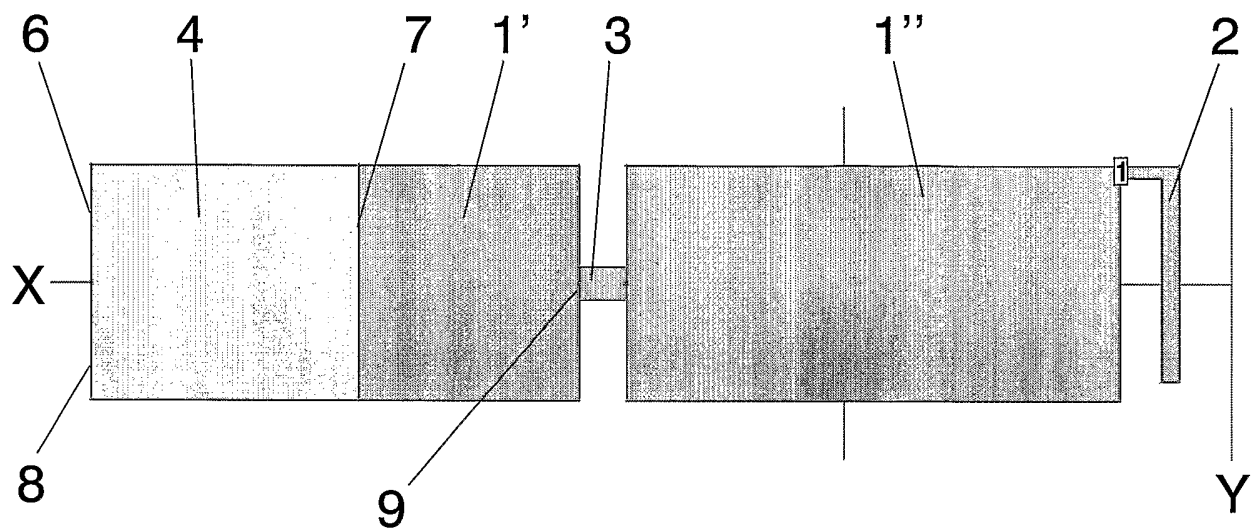


FIG. 6

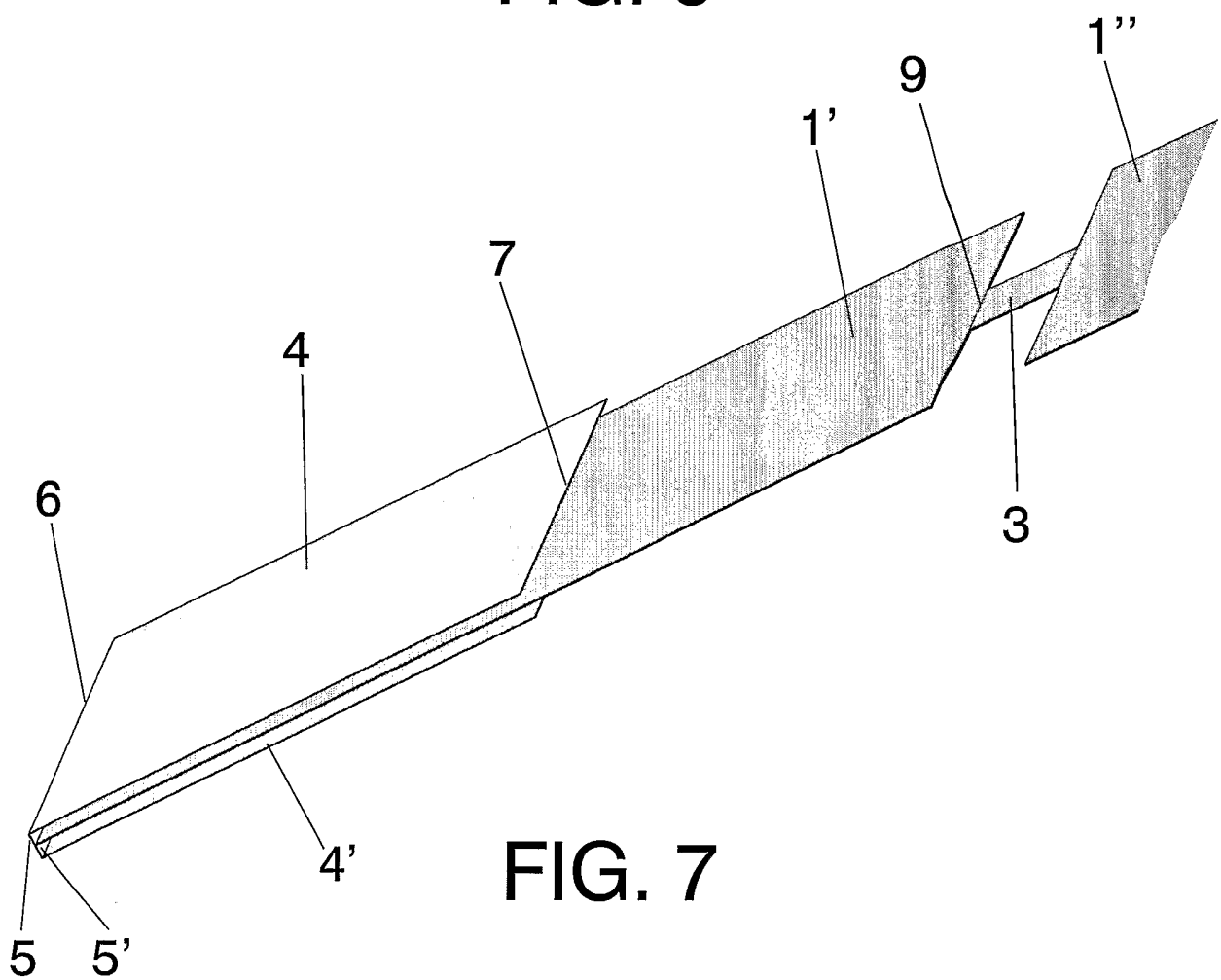
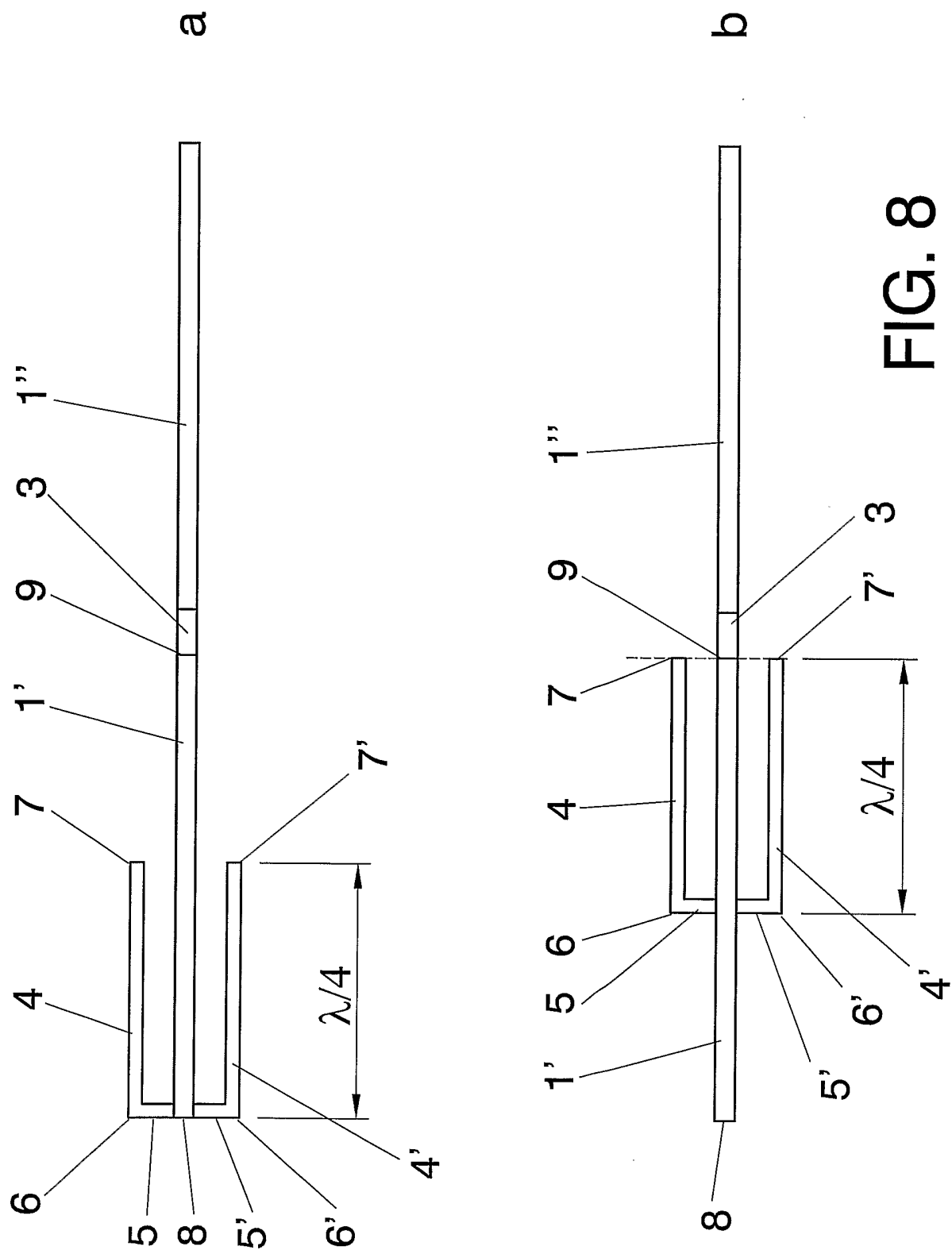
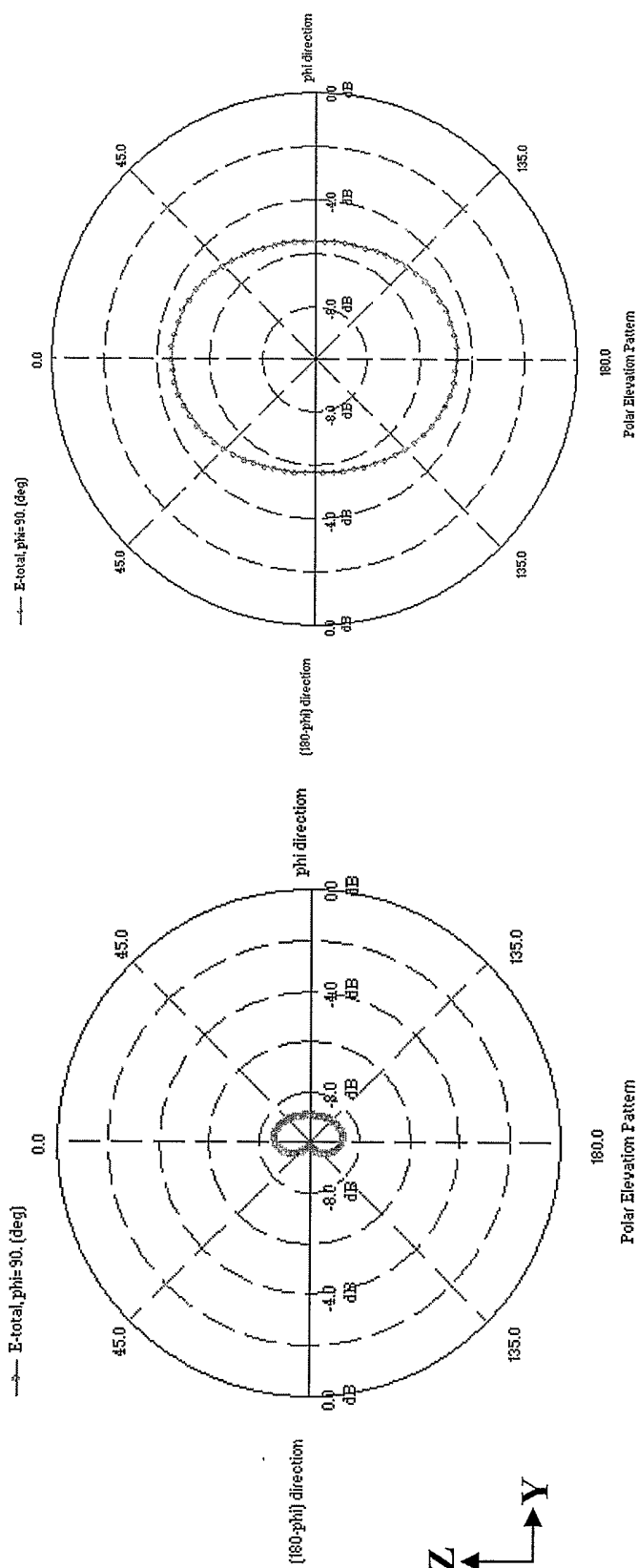


FIG. 7

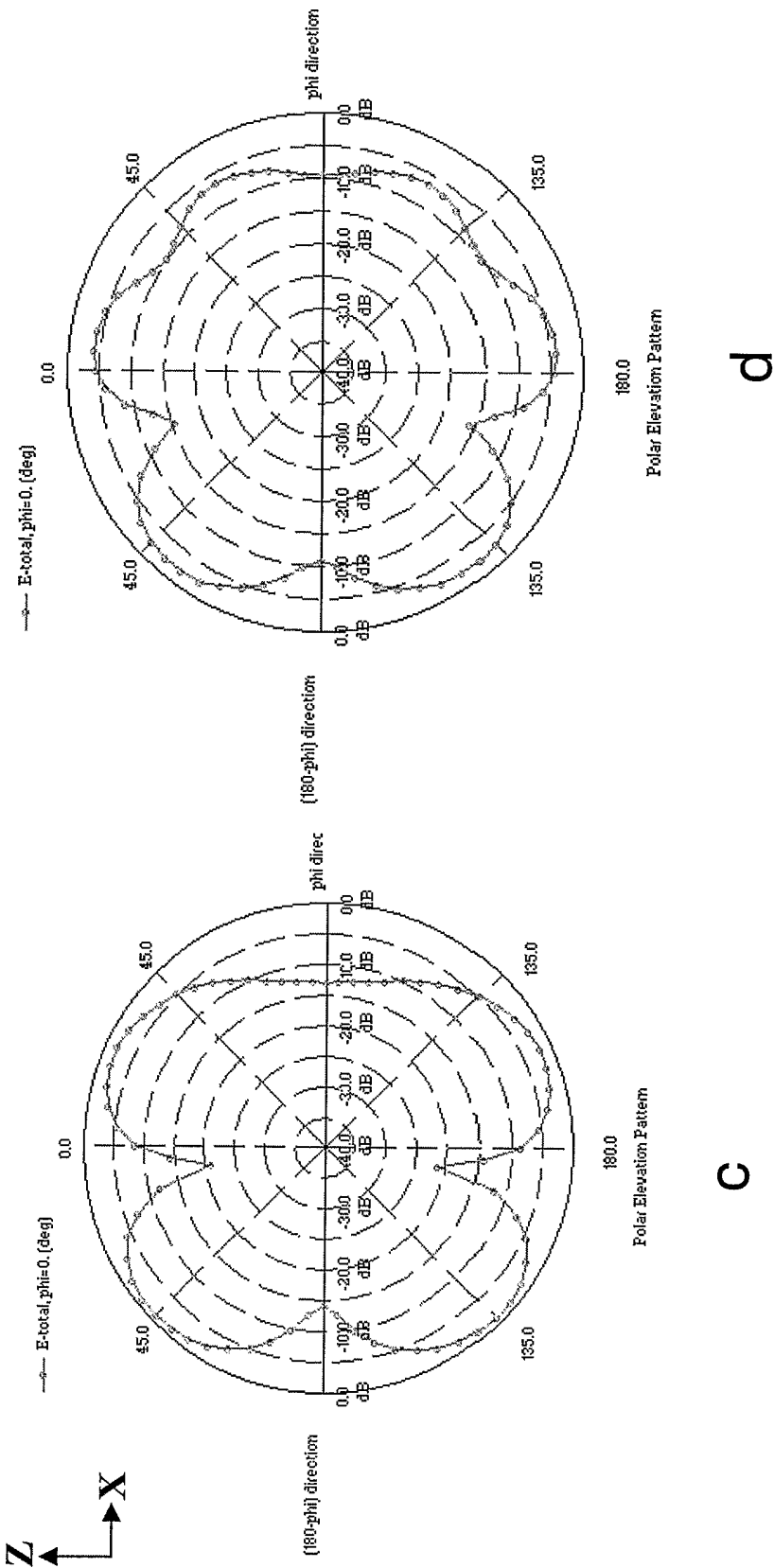




Q

Fig. 9

ॐ



9/12

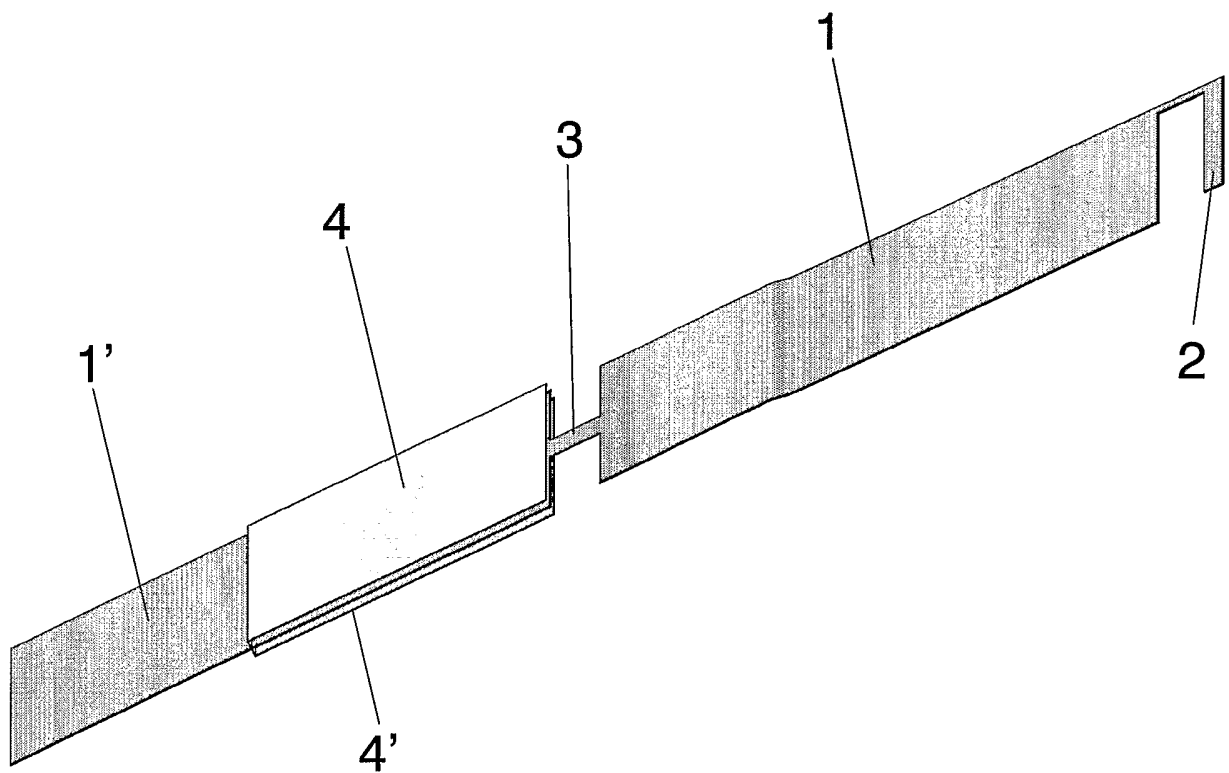


FIG. 10

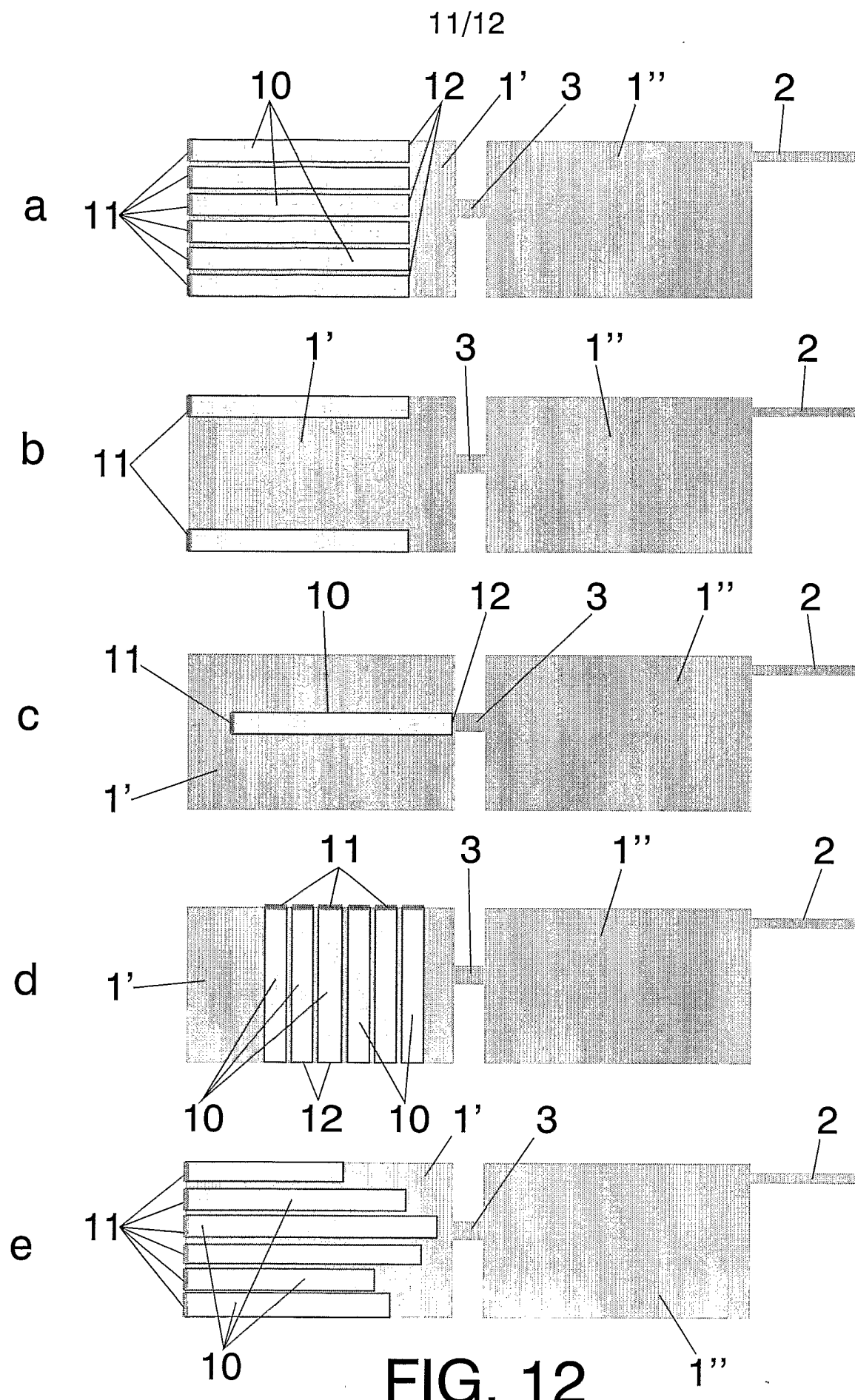


FIG. 12

INTERNATIONAL SEARCH REPORT

PCT/EP2005/002075

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 H01Q1/24 H01Q1/48 H01Q1/52

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)

IPC 7 H01Q H04B

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 practical, search terms used)

EPO-Internal, WPI Data, PAJ, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 02/084784 A (NEC CORPORATION; HANKUI, EIJI; KURIYAMA, TOSHIHIDE) 24 October 2002 (2002-10-24) the whole document	1-15, 19-26, 28, 29
Y	the whole document	16-18, 27
P, X	-& EP 1 403 960 A (NEC CORPORATION) 31 March 2004 (2004-03-31) the whole document	1-15, 19-26, 28, 29
X	US 6 314 273 B1 (MATSUDA TERUKAZU) 6 November 2001 (2001-11-06) the whole document	1-15, 19-26, 29
X	US 6 421 016 B1 (PHILLIPS JAMES P ET AL) 16 July 2002 (2002-07-16) the whole document	1-4, 6-8, 11, 24-26, 29
	----- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in 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 document 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.

Z document member of the same patent family

Date of the actual completion of the international search

7 June 2005

Date of mailing of the international search report

14/06/2005

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer

Moumen, A

INTERNATIONAL SEARCH REPORT

PCT/EP2005/002075

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 03/023900 A (FRACTUS, S. A; QUINTERO ILLERA, RAMIRO; PUENTE BALIARDA, CARLES) 20 March 2003 (2003-03-20) cited in the application the whole document	27
Y	WO 2004/001894 A (FRACTUS, S.A; GALA GALA, DAVID; PUENTE BALIARDA, CARLES; SOLER CASTANY) 31 December 2003 (2003-12-31) the whole document	16-18

INTERNATIONAL SEARCH REPORT

PCT/EP2005/002075

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 02084784	A	24-10-2002	JP 3531621 B2	31-05-2004
			JP 2002314491 A	25-10-2002
			EP 1403960 A1	31-03-2004
			WO 02084784 A1	24-10-2002
			US 2004127249 A1	01-07-2004
EP 1403960	A	31-03-2004	JP 3531621 B2	31-05-2004
			JP 2002314491 A	25-10-2002
			EP 1403960 A1	31-03-2004
			US 2004127249 A1	01-07-2004
			WO 02084784 A1	24-10-2002
US 6314273	B1	06-11-2001	JP 11088209 A	30-03-1999
			CA 2246925 A1	11-03-1999
			KR 272621 B1	15-11-2000
US 6421016	B1	16-07-2002	CN 1483229 A	17-03-2004
			GB 2383196 A ,B	18-06-2003
			WO 02075846 A1	26-09-2002
WO 03023900	A	20-03-2003	WO 03023900 A1	20-03-2003
			BR 0117125 A	28-09-2004
			CN 1545749 A	10-11-2004
			EP 1425820 A1	09-06-2004
			JP 2005503062 T	27-01-2005
			MX PA04002384 A	31-05-2004
			US 2004217916 A1	04-11-2004
WO 2004001894	A	31-12-2003	WO 2004001894 A1	31-12-2003
			AU 2002319262 A1	06-01-2004
			BR 0215790 A	01-03-2005
			EP 1516388 A1	23-03-2005