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## (54) TEN-FREQUENCY BAND ANTENNA

(57) A ten-frequency band antenna includes a carrier (1), a high-frequency segment (2), a low-frequency segment (3), a printed circuit board (PCB) (4) and an inductor (5). The high-frequency segment (2) is arranged on left side of the carrier (1) and the low-frequency segment (3) is arranged on right side of the carrier (1). The radiator (22, 24) on the bottom face (14) of the carrier (1) electrically connects with the micro strip (44) of the PCB (4) and the ground line (46) of the first ground metal face (43) when the carrier (1) is fixed to the PCB (4). The

low-frequency segment (3) is located at an opened area and corresponding to a smaller area (432) of the first ground metal face (43) with such that the low-frequency segment (3) is at a free space to enhance the frequency response of the low-frequency segment (3) and the bandwidth of the high-frequency segment (2). The area and the volume of blind hole (15) on the carrier (1) can adjust the effective dielectric constant to adjust the resonant frequency and bandwidth of the antenna.

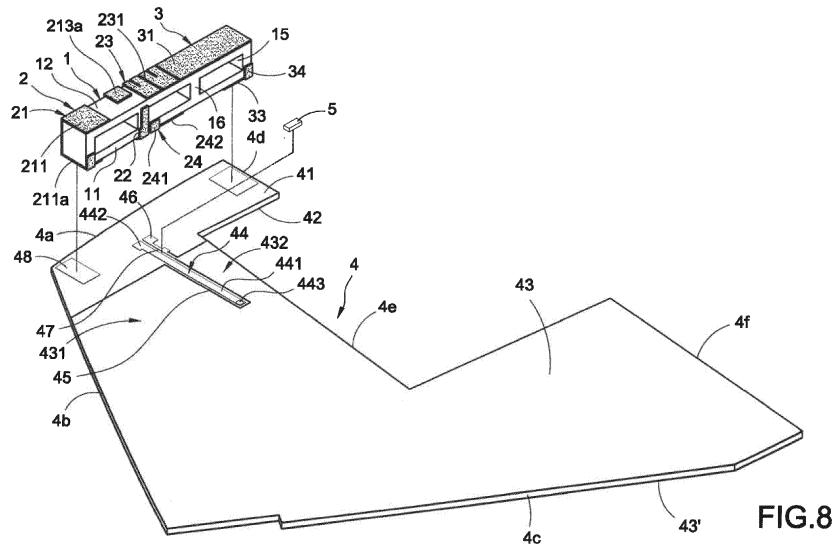


FIG.8

## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

**[0001]** The present invention relates to an antenna, especially to a ten-frequency band antenna for enhancing the frequency response of the low-frequency segment and bandwidth of the high-frequency segment.

#### Description of Prior Art

**[0002]** The current commercially available planar inverted-F antenna (PIFA) is generally formed by printing metal material (such as copper) on printed circuit board (PCB) with two-dimensional printing technology. Alternatively, metal membrane is pressed into three-dimensional multi frequency band antenna.

**[0003]** The multi frequency bands signal transmission/reception can be achieved by changing the two-dimensional radiation patterns or the geometric shape of the three-dimensional radiation bodies. However, the antenna formed on PCB or formed by pressing metal membrane into radiation body need a specific volume to ensure signal transmission/reception quality and prevent signal tuning problem caused by environment. Moreover, the electronic device needs an internal space for arranging the PIFA structure, this causes impact on light weight and compact requirement of the electronic devices.

**[0004]** To overcome above problem, the radiation body of the antenna can be fabricated on a rectangular ceramic carrier. As shown in Figs. 1 and 2, the carrier 101 of the antenna 10 has a high-frequency radiator 102 and a low-frequency radiator 103 on the surface thereof and the carrier 101 is fixed on the PCB 20. The PCB 20 has a ground metal plane 201, a signal feeding micro strip 202 and a ground wire 203 on two faces thereof, where the signal feeding micro strip 202 connects with the ground wire 203 and the radiator of the carrier 101. The high-frequency radiator 102 is arranged on the right side of the carrier 101 and the low-frequency radiator 103 is arranged on the left side of the carrier 101. The antenna 10 is electrically connected to the PCB 20 and the area of the ground metal plane 201 corresponding to the low-frequency radiator 103 is smaller than the area of the ground metal plane 201 corresponding to the high-frequency radiator 102. Therefore, the low-frequency radiator 103 suffers more to the ground shielding and the frequency response (see label A in Fig. 2) is not satisfactory. Moreover, the bandwidth of the high-frequency radiator 102 is not wide enough (only covering 6 bands as shown by label B in Fig. 2). As a result, the signal transmission/reception quality is poor and signal transmission/reception bandwidth is limited.

### SUMMARY OF THE INVENTION

**[0005]** It is an object of the present invention to change the position of the high-frequency segment and the low-frequency segment. The low-frequency segment is corresponding to a smaller area portion of the ground metal face on the PCB when the antenna carrier is fixed to the PCB. Therefore, the low-frequency segment is at a free space to enhance frequency response for the low-frequency segment and the bandwidth for the high-frequency segment.

**[0006]** It is another object of the present invention to provide blind holes and ribs in the carrier. The blind holes and the ribs can reduce the overall weight of the carrier 1 and prevent warp of the carrier. The area ratio of the blind holes and the volume ratio of the blind holes can be used to adjust the effective dielectric constant of the carrier, thus adjusting resonant frequency and the bandwidth.

**[0007]** It is still another object of the present invention to provide an inductor electrically connecting with the ground line and the micro strip to adjust impedance and provide ground for the antenna, thus forming a PIFA dipole antenna.

**[0008]** Accordingly the present invention provides a ten-frequency band antenna, comprising: a carrier being a ceramic rectangular body and comprising a front face, a top face, a back face and a bottom face, the carrier having a plurality of blind holes defined on the front face and concave into the carrier, and at least one rib between two adjacent blind holes; a high-frequency segment comprising an inverse- $\pi$ -shaped radiator, a straight shape radiator, a winding radiator and an L-shaped radiator, wherein the high-frequency segment is arranged on left portions of the front face, the top face, the back face and the bottom face of the carrier if viewing at the front face of the carrier; a low-frequency segment comprising a first rectangular radiator, a second rectangular radiator, a third rectangular radiator and a fourth rectangular radiator, wherein the low-frequency segment is arranged on right portions of the front face, the top face, the back face and the bottom face of the carrier if viewing at the front face of the carrier; a printed circuit board (PCB) having a top side, a left slanting side, a slanting bottom side, a right short side, a recessed side and a right long side, the PCB having a first face and a second face, the first face having a first ground metal face and a micro strip, the micro strip having a front section and a rear section, the front section having a through hole, the micro strip having a front portion extended into the first ground metal face such that a gap is defined between the micro strip and the first ground metal face, the first face of the PCB having an opened area with two fixing ends; an area portion of the first ground metal face, which is from the left slanting side to the gap being larger than an area portion of the first ground metal face, which is from the recessed side to the gap, a ground line extended on the smaller area portion of the first ground metal face extended from

the recessed side to the gap, a separation defined between the ground line and the rear segment of the micro strip, the first face having an opened area with two fixed ends; an inductor arranged across the separation with one end electrically connecting with the rear section of the micro strip and another end electrically connecting with the ground line, wherein the two fixed ends of the opened area of the first face are fixed to the bottom face of the carrier such that the low-frequency segment is corresponding the recessed side and corresponding to the smaller area portion of the first ground metal face extended from the recessed side to the gap and the low-frequency segment is at a free space to enhance a frequency response of the low-frequency segment, the inverse- $\pi$ -shaped radiator, the straight shape radiator, and the winding radiator couple to each other to enhance a bandwidth of the high-frequency segment.

**[0009]** According to one aspect of the present invention, an area ratio of the blind holes on the front face and a volume ratio of the blind holes with respect to the carrier is adjustable to adjust an effective dielectric constant of the carrier, thus adjusting resonant frequency and the bandwidth.

**[0010]** According to another aspect of the present invention, the area ratio of the blind holes on the front face is 30%-50%.

**[0011]** According to still another aspect of the present invention, the area ratio of the blind holes on the front face is 40%.

**[0012]** According to still another aspect of the present invention, the volume ratio of the blind holes with respect to the carrier is 20%-30%.

**[0013]** According to still another aspect of the present invention, the volume ratio of the blind holes with respect to the carrier is 24%.

**[0014]** According to still another aspect of the present invention, the inverse- $\pi$ -shaped radiator has a first straightline portion, a second straightline portion and an L shaped portion, the first straightline portion is arranged on edges of the front face, the top face, the back face and the bottom face of the carrier, a portion of the first straightline portion on the bottom is used as fixed point for PCB.

**[0015]** According to still another aspect of the present invention, the straight shape radiator electrically connects to one side of the second straightline portion, the straight shape radiator is arranged on edges of the front face and the bottom face of the carrier, one end of the straight shape radiator is adjacent to the winding radiator for coupling and a portion of the straight shape radiator arranged on the bottom face is used as signal feeding point.

**[0016]** According to still another aspect of the present invention, one end of the winding radiator electrically connects with one end of the second straightline portion and another end of the winding radiator electrically connects with low-frequency segment such that a short side of the L-shaped radiator of the inverse- $\pi$ -shaped radiator is cou-

pling to the winding radiator.

**[0017]** According to still another aspect of the present invention, pitches of the winding radiator are around 0.15 mm~0.3 mm to provide LC resonance with 2400MHZ~2700MHZ resonant frequency.

**[0018]** According to still another aspect of the present invention, the L-shaped radiator is arranged on the front face and bottom face of the carrier, the short side of the L-shaped radiator is parallel to the straight shape radiator, a long side of the L-shaped radiator is vertical to the straight shape radiator and parallel to the winding radiator, the long side of the L-shaped radiator provides ground point.

**[0019]** According to still another aspect of the present invention, the high-frequency segment provides a fourth frequency band, a fifth frequency band, a sixth frequency band, a seventh frequency band, an eighth frequency band, a ninth frequency band and a tenth frequency band, and the fourth frequency band, the fifth frequency band, the sixth frequency band, the seventh frequency band, the eighth frequency band, the ninth frequency band and the tenth frequency band are within 1710MHZ~6000MHZ.

**[0020]** According to still another aspect of the present invention, the high-frequency segment provides a first frequency band, a second frequency band, and a third frequency band, and the first frequency band, the second frequency band, and the third frequency band are within 700MHZ~960MHZ.

**[0021]** According to still another aspect of the present invention, the second face has a second ground metal face, the through hole is opened to the second ground metal face and electrically connects with a signal feeding end of a coaxial cable, the second ground metal face electrically connects with a ground end of the coaxial cable.

#### BRIEF DESCRIPTION OF DRAWING

**[0022]** The present disclosed example itself, however, may be best understood by reference to the following detailed description of the present disclosed example, which describes an exemplary embodiment of the present disclosed example, taken in conjunction with the accompanying drawings, in which:

Fig. 1 shows a conventional multi-band antenna.

Fig. 2 shows the reflection coefficients of the multi-band antenna in Fig. 1.

Fig. 3 shows the front perspective view of the carrier of the ten-frequency band antenna according to the present invention.

Fig. 4 shows the top perspective view of the carrier of the ten-frequency band antenna according to the present invention.

Fig. 5 shows the back perspective view of the carrier of the ten-frequency band antenna according to the present invention.

Fig. 6 shows the back perspective view of the carrier of the ten-frequency band antenna according to the present invention.

Fig. 7 shows expanded view of the metal radiators of the carrier of the ten-frequency band antenna according to the present invention.

Fig. 8 shows the exploded view of the ten-frequency band antenna and the PCB.

Fig. 9 shows the backside view of the ten-frequency band antenna and the PCB.

Fig. 10 shows the electric connection of the ten-frequency band antenna and the PCB.

Fig. 11 shows the reflection loss curve of the ten-frequency band antenna of the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

**[0023]** Fig. 3 shows the front perspective view of the carrier of the ten-frequency band antenna according to the present invention; Fig. 4 shows the top perspective view of the carrier of the ten-frequency band antenna according to the present invention; Fig. 5 shows the back perspective view of the carrier of the ten-frequency band antenna according to the present invention; Fig. 6 shows the back perspective view of the carrier of the ten-frequency band antenna according to the present invention; and Fig. 7 shows expanded view of the metal radiators of the carrier of the ten-frequency band antenna according to the present invention. The ten-frequency band antenna according to the present invention comprises a carrier 1, a high-frequency segment 2, and a low-frequency segment 3.

**[0024]** The carrier 1 is a ceramic rectangular body with a front face 11, a top face 12, a back face 13 and a bottom face 14. The front face 11 has a plurality of blind holes 15 defined thereon and each two blind holes have a rib 16 therebetween. The blind holes 15 and the ribs 16 can reduce the overall weight of the carrier 1 and prevent warp of the carrier 1. The area ratio of the blind holes 15 on the front face 11 and the volume ratio of the blind holes 15 with respect to the carrier 1 can be used to adjust the effective dielectric constant of the carrier 1, thus adjusting resonant frequency and the bandwidth. The area ratio of the blind holes 15 on the front face 11 is around 30%-50%, and more particularly can be 40%. The volume ratio of the blind holes 15 with respect to the carrier 1 is 20%-30% and more particularly can be 24%. Moreover, the shape and the symmetric degree of the blind holes 15 can also be adjusted.

**[0025]** When viewing from the front face 11 of the carrier 1, the high-frequency segment 2 is arranged on the left side of the carrier 1 and has an inverse- $\pi$ -shaped radiator 21, a straight shape radiator 22, a winding radiator 23 and an L-shaped radiator 24. The inverse- $\pi$ -shaped radiator 21 has a first straightline portion 211, a second straightline portion 212 and an L-shaped portion 213. The first straightline portion 211 is arranged on edges of the front face 11, the top face 12, the back face 13 and the

bottom face 14. The portion of the first straightline portion 211 on the bottom face 14, namely the bottom first straightline portion 211a is used as fixed point for PCB (not shown). The second straightline portion 212 of the 5 inverse- $\pi$ -shaped radiator 21 connects with the straight shape radiator 22 at one edge thereof. The straight shape radiators 22 are arranged on the front face 11 and the bottom face 14, respectively. One end of the straight shape radiator 22 is adjacent to the winding radiator 23 such that the coupling therebetween provides 10 4900MHZ~6000MHZ bandwidth. The straight shape radiator 22 arranged on the bottom face 14 is used as signal feeding point. One end of the winding radiator 23 electrically connects with one end of the second straightline portion 212 and another end of the winding radiator 23 electrically connects with low-frequency segment 3. The 15 short side 213a of the L shaped portion 213 and the winding radiator 23 have coupling therebetween to provide 3500MHZ bandwidth. The pitches of the winding radiator 23 are around 0.15 mm~0.3 mm to provide LC resonance with 20 2400MHZ~2700MHZ resonant frequency. The L-shaped radiator 24 is arranged on the front face 11 and the bottom face 14. The short side 241 of the L-shaped radiator 24 is parallel to the straight shape radiator 22, 25 the long side 242 of the L-shaped radiator 24 is vertical to the straight shape radiator 22 and parallel to the winding radiator 23. In the shown embodiment, the longer side 242 of the L-shaped radiator 24 is used as ground end. In the shown embodiment, high-frequency segment 30 2 provides the fourth frequency band, the fifth frequency band, the sixth frequency band, the seventh frequency band, the eighth frequency band, the ninth frequency band and the tenth frequency band. The frequency range of the fourth frequency band, the fifth frequency band, 35 the sixth frequency band, the seventh frequency band, the eighth frequency band, the ninth frequency band and the tenth frequency band is between 1710MHZ and 6000MHZ, and can be used in GSM, WCDMA, WIFI, LTE, WIMAX and 802.11ac communication system.

**[0026]** When viewing from the front face 11 of the carrier 1, the low-frequency segment 3 is arranged on the right side of the carrier 1 and has a first rectangular radiation body 31, a second rectangular radiation body 32, a third rectangular radiation body 33 and a fourth rectangular radiation body 34, where each of the rectangular radiation bodies has different area and is respectively arranged on the front face 11, the top face 12, the back face 13 and the bottom face 14 of the carrier 1. The third rectangular radiation body 33 provides fixing points with 40 the printed circuit board. In the shown embodiment, the low-frequency segment 3 provides the first frequency band, the second frequency band, and the third frequency band. The frequency range of the first frequency band, the second frequency band, and the third frequency band 45 is between 700MHZ and 960MHZ, and can be used in LTE and GMS communication system.

**[0027]** Figs. 8 to 10 show the exploded view, the backside view and the electric connection of the ten-frequency

band antenna and the PCB. The ten-frequency band antenna further comprises a PCB 4 fixed to the carrier 1 and the PCB has a top side 4a, a left slanting side 4b, a bottom slanting side 4c, a right short side 4d, a recessed side 4e and a right long side 4f. Moreover, the PCB 4 has a first face 41 and a second face 42. The first face 41 has a first ground metal face 43 and a micro strip 44. The micro strip 44 has a front section 441 and a rear section 442. The front section 441 has a through hole 443 and extends into the first ground metal face 43 such that a gap 45 is defined between the front section 441 and the first ground metal face 43. Moreover, the area portion 431 of the first ground metal face 43, which is from the left slanting side 4b to the gap 45, is larger than the area portion 432 of the first ground metal face 43, which is from the recessed side 4e to the gap 45.

**[0028]** Moreover, a ground line 46 is extended on the area portion 432 of the first ground metal face 43, which is from the recessed side 4e to the gap 45. The ground line 46 is parallel to the rear section 442 of the micro strip 44. A separation 47 is defined between the ground line 46 and the rear section 442 of the micro strip 44. An inductor 5 is connected between the ground line 46 and the rear section 442 of the micro strip 44 and cross the separation 47 to adjust impedance and provide ground for the antenna, thus forming a PIFA dipole antenna. The opened area of the first face 41 has two corresponding fixed ends 48 for fixed connection with the first straightline portion 211a and the third rectangular radiation body 33.

**[0029]** The second face 42 further has a second ground metal face 43', where the through hole 443 is opened to the second ground metal face 43' and electrically connects with a signal feeding end (not shown) of a coaxial cable. The second ground metal face 43' electrically connects with the ground end of the coaxial cable.

**[0030]** When the carrier 1 is fixed to the PCB 4, the two fixed ends 48 are fixed to the first straightline portion 211a and the third rectangular radiation body 33 respectively. The straight shape radiator 22 on the bottom face 14 electrically connects the micro strip 44. The long side 242 of the L-shaped radiator 24 electrically connects with the ground line 46. After fixing the carrier 1, the low-frequency segment 3 is arranged on the opened area and corresponding to the recessed side 4e of the PCB 4 and corresponding to the smaller area portion 432 of the first ground metal face 43 such that the low-frequency segment 3 is located at a free space to enhance the frequency response of the low-frequency segment 3.

**[0031]** Fig. 11 shows the reflection loss curve of the ten-frequency band antenna of the present invention. With reference also to Fig. 10, after fixing the carrier 1 to the PCB 4, the low-frequency segment 3 is arranged on the opened area and corresponding to the recessed side 4e of the PCB 4 and the smaller area portion 432 of the first ground metal face 43 such that the low-frequency segment 3 is at a free space with less shielding. The ten-frequency band antenna of the present invention has better frequency response for the low-frequency segment 3

and higher bandwidth for the high-frequency segment 2. Moreover, the low-frequency segment 3 provides the first frequency band, the second frequency band, and the third frequency band. The frequency range of the first frequency band, the second frequency band, and the third frequency band is between 700MHZ and 960MHZ, as indicated by mark C in Fig. 11. The high-frequency segment 2 provides the fourth frequency band, the fifth frequency band, and the sixth frequency band with frequency range between 1710MHZ and 2710MHZ, as indicated by mark D in Fig. 11. The high-frequency segment 2 provides the seventh frequency band with frequency range 2400MHZ~2500MHZ and the eighth frequency band with frequency range 2600MHZ~2700MHZ, as indicated by mark D in Fig. 11. The high-frequency segment 2 provides the ninth frequency band with frequency range 3500MHZ~3700MHZ, as indicated by mark E in Fig. 11. The high-frequency segment 2 provides the tenth frequency band with frequency range 4900MHZ~6000MHZ, as indicated by mark F in Fig. 11.

**[0032]** The invention may further include the following items:

1. A ten-frequency band antenna, comprising:

a carrier (1) being a ceramic rectangular body and comprising a front face (11), a top face (12), a back face (13) and a bottom face (14), the carrier (1) having a plurality of blind holes (15) defined on the front face (11) and concave into the carrier (1), and at least one rib (16) between two adjacent blind holes (15);

a high-frequency segment (2) comprising an inverse-T-shaped radiator (21), a straight shape radiator (22), a winding radiator (23) and an L-shaped radiator (24), wherein the high-frequency segment (2) is arranged on left portions of the front face (11), the top face (12), the back face (13) and the bottom face (14) of the carrier (1) if viewing from the front face (11) of the carrier (1);

a low-frequency segment (3) comprising a first rectangular radiator (31), a second rectangular radiator (32), a third rectangular radiator (33) and a fourth rectangular radiator (34), wherein the low-frequency segment (3) is arranged on right portions of the front face (11), the top face (12), the back face (13) and the bottom face (14) of the carrier (1) if viewing from the front face (11) of the carrier (1);

a printed circuit board (PCB) (4) having a top side (4a), a left slanting side (4b), a slanting bottom side (4c), a right short side (4d), a recessed side (4e) and a right long side (4f), the PCB (4) having a first face (41) and a second face (42), the first face (41) having a first ground metal face (43) and a micro strip (44), the micro strip (44) having a front section (441) and a rear section

(442), the front section (441) having a through hole (443), the front section (441) extended into the first ground metal face such that a gap (45) is defined between the micro strip (44) and the first ground metal face (43);  
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 an area portion (431) of the first ground metal face (43), which is from the left slanting side (4b) to the gap (45) being larger than an area portion (432) of the first ground metal face (43), which is from the recessed side (4e) to the gap (45), a ground line (46) extended on the smaller area portion (432) of the first ground metal face (43) extended from the recessed side (4e) to the gap (45), a separation (47) defined between the ground line (46) and the rear section (442) of the micro strip (44), the first face (41) having an opened area with two fixed ends (48);  
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 an inductor (5) arranged across the separation (47) with one end electrically connecting with the rear section (442) of the micro strip (44) and another end electrically connecting with the ground line (46), wherein the two fixed ends (48) of the opened area of the first face (41) are fixed to the bottom face (14) of the carrier (1) such that the low-frequency segment (3) is corresponding the recessed side (4e) and corresponding to the smaller area portion (432) of the first ground metal face (43) extended from the recessed side (4e) to the gap (45) and the low-  
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 frequency segment (3) is at a free space to enhance a frequency response of the low-frequency segment (3), the inverse- $\pi$ shaped radiator (21), the straight shape radiator (22), and the winding radiator (23) couple to each other to enhance a bandwidth of the high-frequency segment (2).  
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2. The ten-frequency band antenna in item 1, wherein in an area ratio of the blind holes (15) on the front face (11) and a volume ratio of the blind holes (15) with respect to the carrier (1) is adjustable to adjust an effective dielectric constant of the carrier (1), thus adjusting resonant frequency and the bandwidth.  
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3. The ten-frequency band antenna in item 2, wherein in the area ratio of the blind holes (15) on the front face (11) is 30%-50%.  
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4. The ten-frequency band antenna in item 3, wherein in the area ratio of the blind holes (15) on the front face (11) is 40%.  
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5. The ten-frequency band antenna in item 2, wherein in the volume ratio of the blind holes (15) with respect to the carrier (1) is 20%-30%.  
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6. The ten-frequency band antenna in item 5, wherein in the volume ratio of the blind holes (15) with respect

to the carrier (1) is 24%.

7. The ten-frequency band antenna in item 1, wherein in the inverse- $\pi$ shaped radiator (21) has a first straightline portion (211), a second straightline portion (212) and an L shaped portion (213), the first straightline portion (211) is arranged on edges of the front face (11), the top face (12), the back face (13) and the bottom face (14) of the carrier (1), a portion of the first straightline portion (211) on the bottom face (14) is used as fixed point for PCB.

8. The ten-frequency band antenna in item 7, wherein in the straight shape radiator (22) electrically connects to one side of the second straightline portion (212), the straight shape radiator (22) is arranged on edges of the front face (11) and the bottom face (14) of the carrier (1), one end of the straight shape radiator (22) is adjacent to the winding radiator (23) for coupling and a portion of the straight shape radiator (22) arranged on the bottom face (14) is used as signal feeding point.

9. The ten-frequency band antenna in item 8, wherein in one end of the winding radiator (23) electrically connects with one end of the second straightline portion (212) and another end of the winding radiator (23) electrically connects with low-frequency segment (3) such that a short side (213a) of the L-shaped portion (213) of the inverse- $\pi$ shaped radiator (21) is coupling to the winding radiator (23).

10. The ten-frequency band antenna in item 8, wherein pitches of the winding radiator (23) are 0.15 mm-0.3 mm to provide LC resonance with 2400MHZ-2700MHZ resonant frequency.

11. The ten-frequency band antenna in item 10, wherein the L-shaped radiator (24) is arranged on the front face (11) and bottom face (14) of the carrier, the short side (241) of the L-shaped radiator (24) is parallel to the straight shape radiator (22), a long side (242) of the L-shaped radiator (24) is vertical to the straight shape radiator (22) and parallel to the winding radiator (23), the long side (242) of the L-shaped radiator (24) provides ground point.

12. The ten-frequency band antenna in item 11, wherein the high-frequency segment (2) provides a fourth frequency band, a fifth frequency band, a sixth frequency band, a seventh frequency band, an eighth frequency band, a ninth frequency band and a tenth frequency band, and the fourth frequency band, the fifth frequency band, the sixth frequency band, the seventh frequency band, the eighth frequency band, the ninth frequency band and the tenth frequency band are within 1710MHZ-6000MHZ.

13. The ten-frequency band antenna in item 1, wherein the low-frequency segment (3) provides a first frequency band, a second frequency band, and a third frequency band, and the first frequency band, the second frequency band, and the third frequency band are within 700MHZ-960MHZ.

14. The ten-frequency band antenna in item 1, wherein the second face (42) has a second ground metal face (43'), the through hole (443) is opened to the second ground metal face (43') and electrically connects with a signal feeding end of a coaxial cable, the second ground metal face (43') electrically connects with a ground end of the coaxial cable.

## Claims

1. A ten-frequency band antenna, comprising:

a carrier (1) comprising a front face (11), a top face (12), a back face (13) and a bottom face (14), and having a plurality of blind holes (15) defined on the front face (11) and at least one rib (16) between two adjacent blind holes (15); a high-frequency segment (2) comprising four radiating sub-segments including an inverse  $\Pi$ -shaped radiator (21) positioned on at least one face of the carrier (1), and a winding radiator (23) positioned on at least two faces of the carrier (1), wherein the high-frequency segment (2) is positioned at a first end of the length of the carrier (1); and a low-frequency segment (3) wherein the low-frequency segment (3) is positioned at a second end of the length of the carrier (1).

2. The ten-frequency band antenna of claim 1, wherein an area ratio of the blind holes (15) and a volume ratio of the blind holes (15) with respect to the carrier (1) is adjustable to adjust an effective dielectric constant of the carrier (1), thus adjusting resonant frequency and the bandwidth.

3. The ten-frequency band antenna of claim 2, wherein the area ratio of the blind holes (15) on the front face (11) is 30%-50%; wherein, preferably, the area ratio of the blind holes (15) on the front face (11) is 40%.

4. The ten-frequency band antenna of claim 2, wherein the volume ratio of the blind holes (15) with respect to the carrier (1) is 20%-30%.

5. The ten-frequency band antenna of claim 4, wherein the volume ratio of the blind holes (15) with respect to the carrier (1) is 24%.

6. The ten-frequency band antenna of claim 1, wherein the inverse  $\Pi$ -shaped radiator (21) has a first straight line portion (211), a second straight line portion (212) and an L shaped portion (213), the first straight line portion (211) is arranged on the front face (11), the top face (12), the back face (13) and the bottom face (14) of the carrier (1), a portion of the first straight line portion (211) on the bottom face (14) is used as fixed point for a PCB (4).

7. The ten-frequency band antenna of claim 6, wherein one of the four radiating sub-segments is a straight shape radiator (22) which electrically connects to one side of the second straight line portion (212), the straight shape radiator (22) is arranged on edges of the front face (11) and the bottom face (14) of the carrier (1), and a portion of the straight shape radiator (22) is arranged on the bottom face (14) and is used as signal feeding point.

8. The ten-frequency band antenna of claim 1, wherein one end of the winding radiator (23) electrically connects with one end of the second straight line portion (212) of the inverse  $\Pi$ -shaped radiator (21) and another end of the winding radiator (23) electrically connects with low-frequency segment (3) such that a short side of the L-shaped radiator (213) of the inverse  $\delta$ -shaped radiator (21) is coupling to the winding radiator (23).

9. The ten-frequency band antenna of claim 1, wherein pitches of the winding radiator (23) are around 0.15 mm to about 0.3 mm to provide LC resonance with 2400 MHZ to about 2700 MHZ resonant frequency.

10. The ten-frequency band antenna of claim 1, wherein one of the four radiating sub-segments is an L-shaped radiator (24) arranged on the front face (11) and bottom face (14) of the carrier (1), the short side of the L-shaped radiator is parallel to the straight shape radiator (22), a long side of the L-shaped radiator (24) is vertical to the straight shape radiator (22) and parallel to the winding radiator (23), the long side of the L-shaped radiator (24) provides ground point.

11. The ten-frequency band antenna of claim 10, wherein in the high-frequency segment (2) provides a fourth frequency band, a fifth frequency band, a sixth frequency band, a seventh frequency band, an eighth frequency band, a ninth frequency band and a tenth frequency band, and the fourth frequency band, the fifth frequency band, the sixth frequency band, the seventh frequency band, the eighth frequency band, the ninth frequency band and the tenth frequency band are within 1710 MHZ to about 6000 MHZ.

12. The ten-frequency band antenna of claim 1, wherein

the low-frequency segment (3) provides a first frequency band, a second frequency band, and a third frequency band, and the first frequency band, the second frequency band, and the third frequency band are within 700 MHZ to about 960 MHZ. 5

13. A PCB (4) for use with an antenna comprising:

a top side (4a), a left slanting side (4b), a slanting bottom side (4c), a right short side (4d), a recessed side (4e) and a right long side (4f), the PCB (4) having a first face (41) and a second face (42), the first face (41) having a first ground metal face (43) and a micro strip (44), the micro strip (44) having a front section (441) and a rear section (442), the front section (441) having a through hole (443), wherein the front section (441) of the micro strip (44) extends into the first ground metal face (43) such that a gap (45) is defined between the micro strip (44) and the first ground metal face (43), and the first face (41) of the PCB (4) has an opened area with two fixing ends. 10 15 20

14. The PCB (4) of claim 13, wherein the second face (42) of the PCB (4) has a second ground metal face (43'), the through hole (443) is opened to the second ground metal face (43') and electrically connects with a signal feeding end of a coaxial cable, the second ground metal face (43') electrically connects with a ground end of the coaxial cable. 25 30

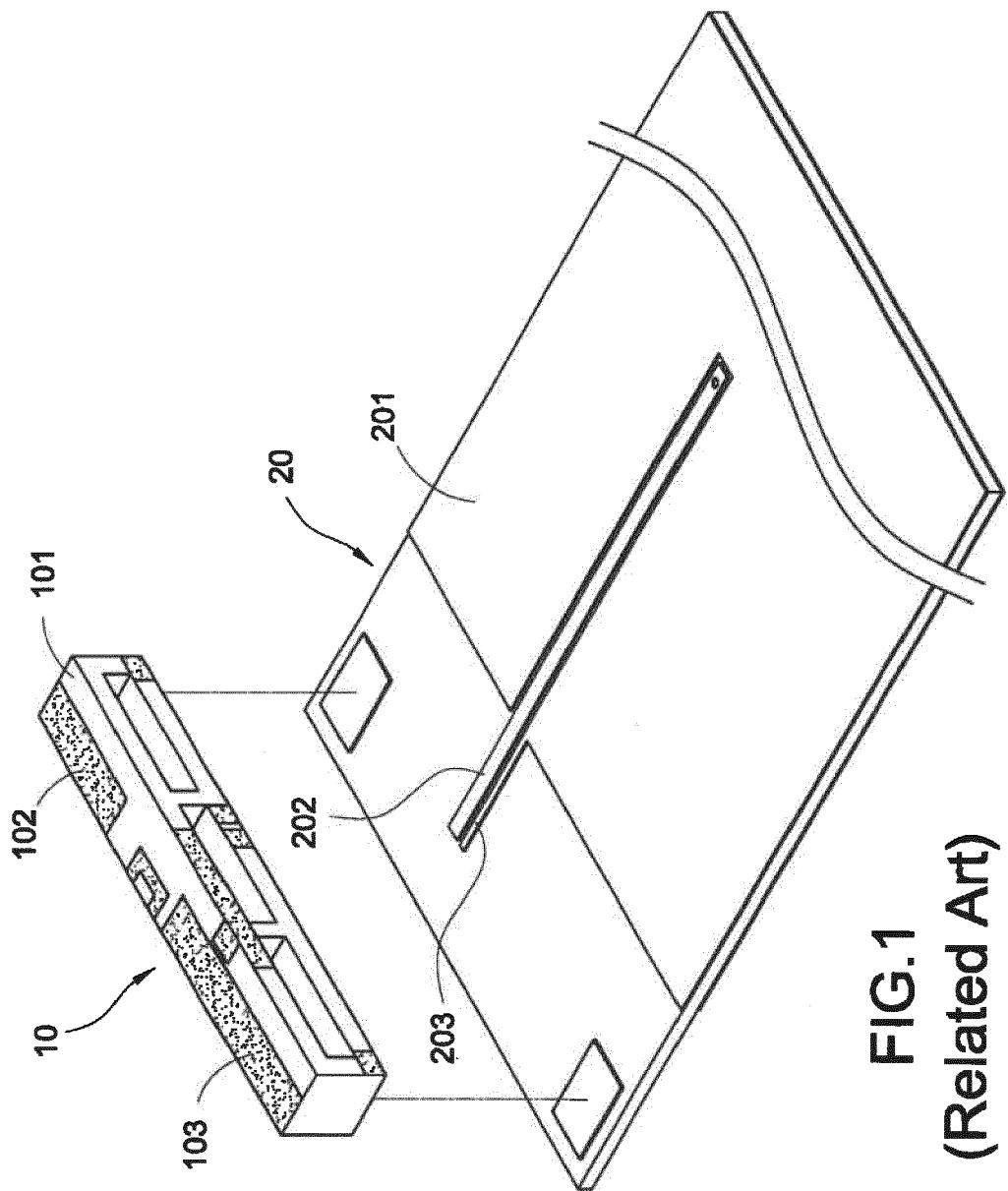
15. A system comprising the ten-frequency band antenna of any one of claims 1 to 12 engaged with the PCB (4) of claim 13 or 14. 35

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**FIG. 1**  
(Related Art)

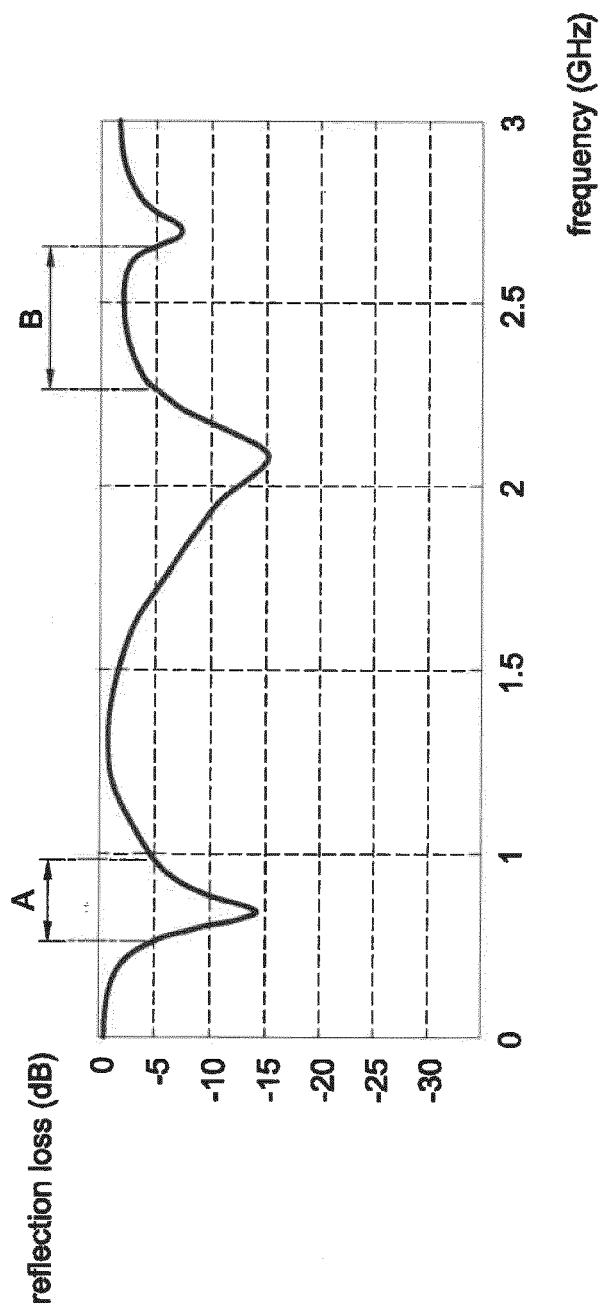


FIG.2  
(Related Art)

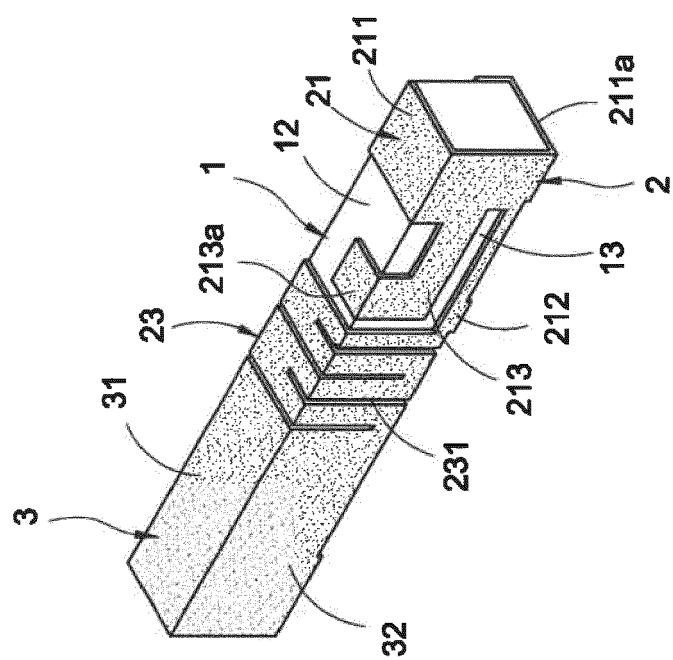
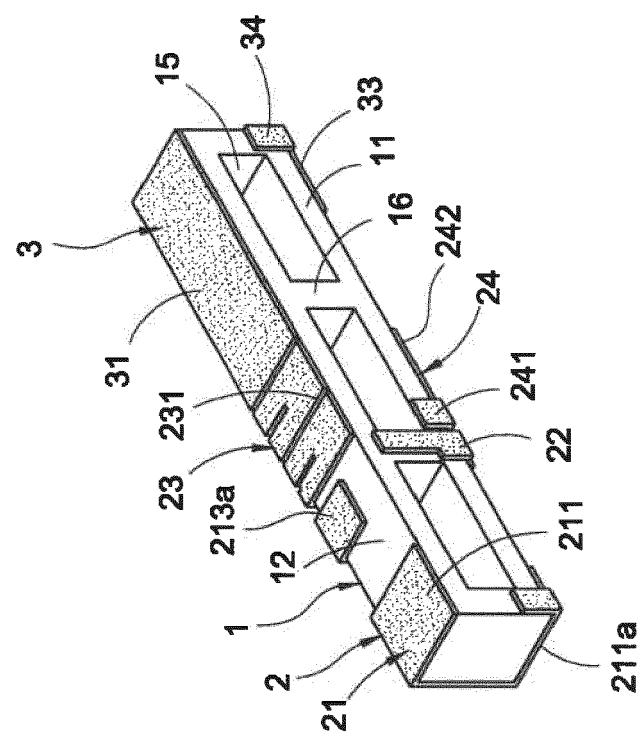


FIG. 4



3.  
EIGEN

FIG.6

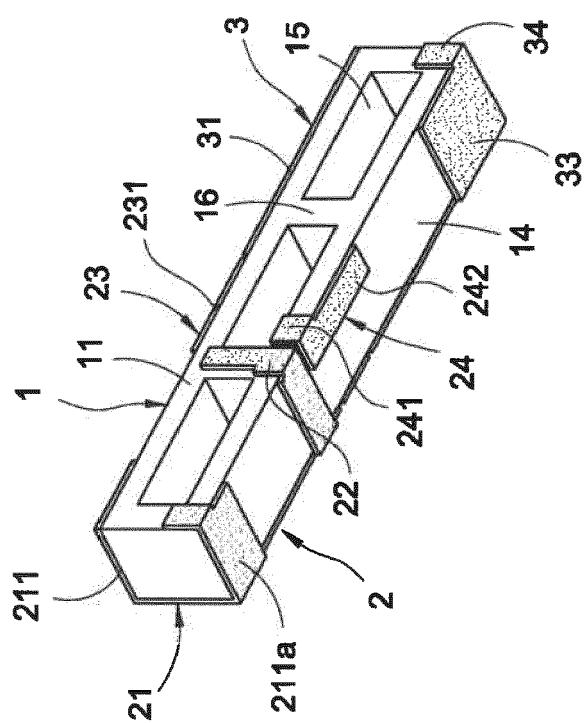
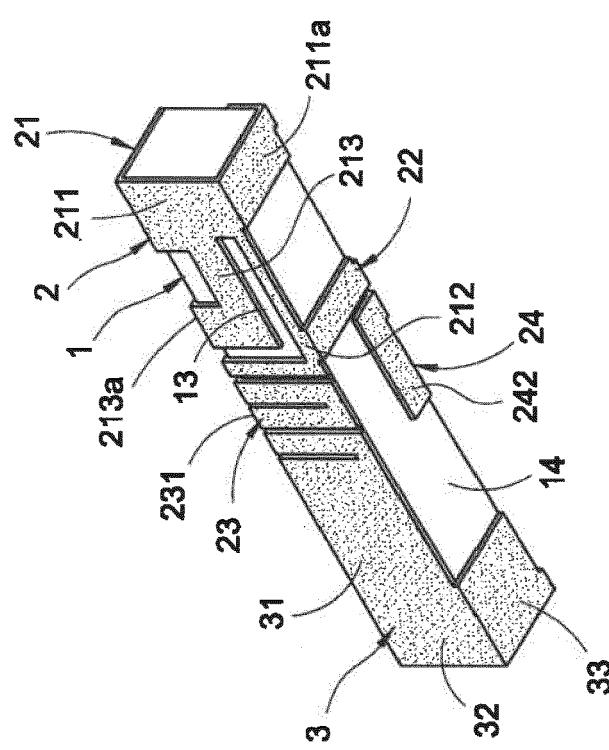


FIG.5



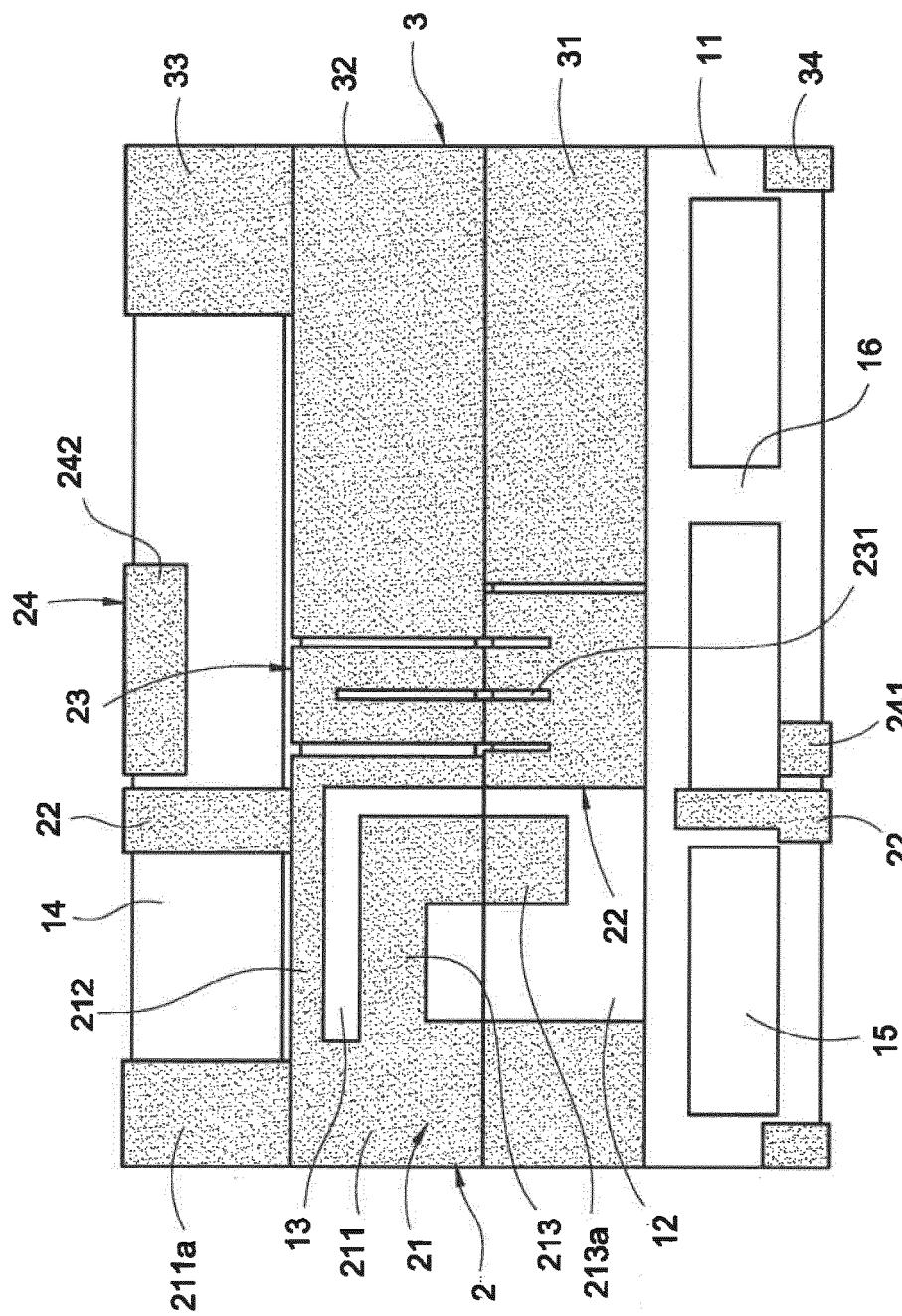
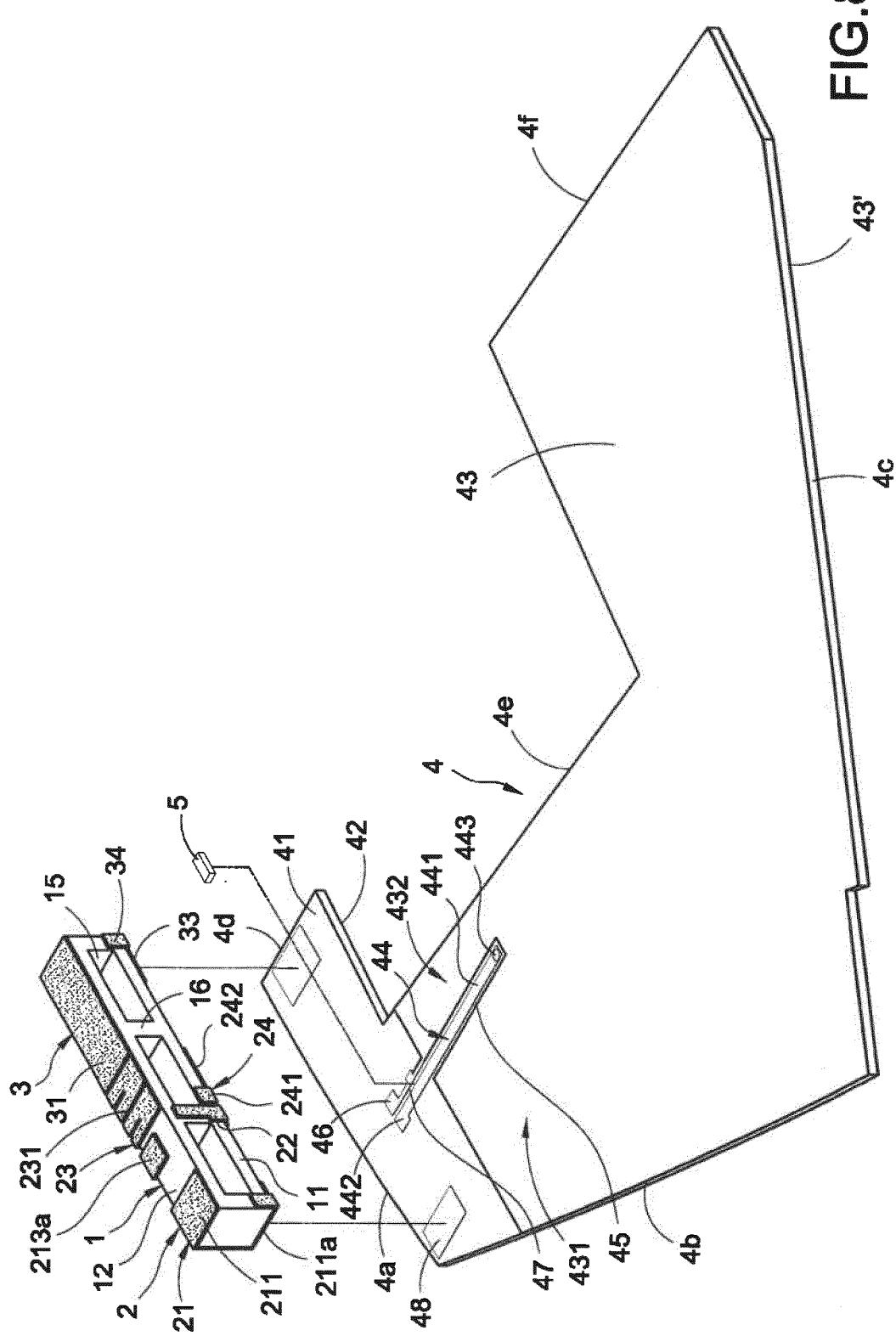


FIG.7



8.  
E  
II

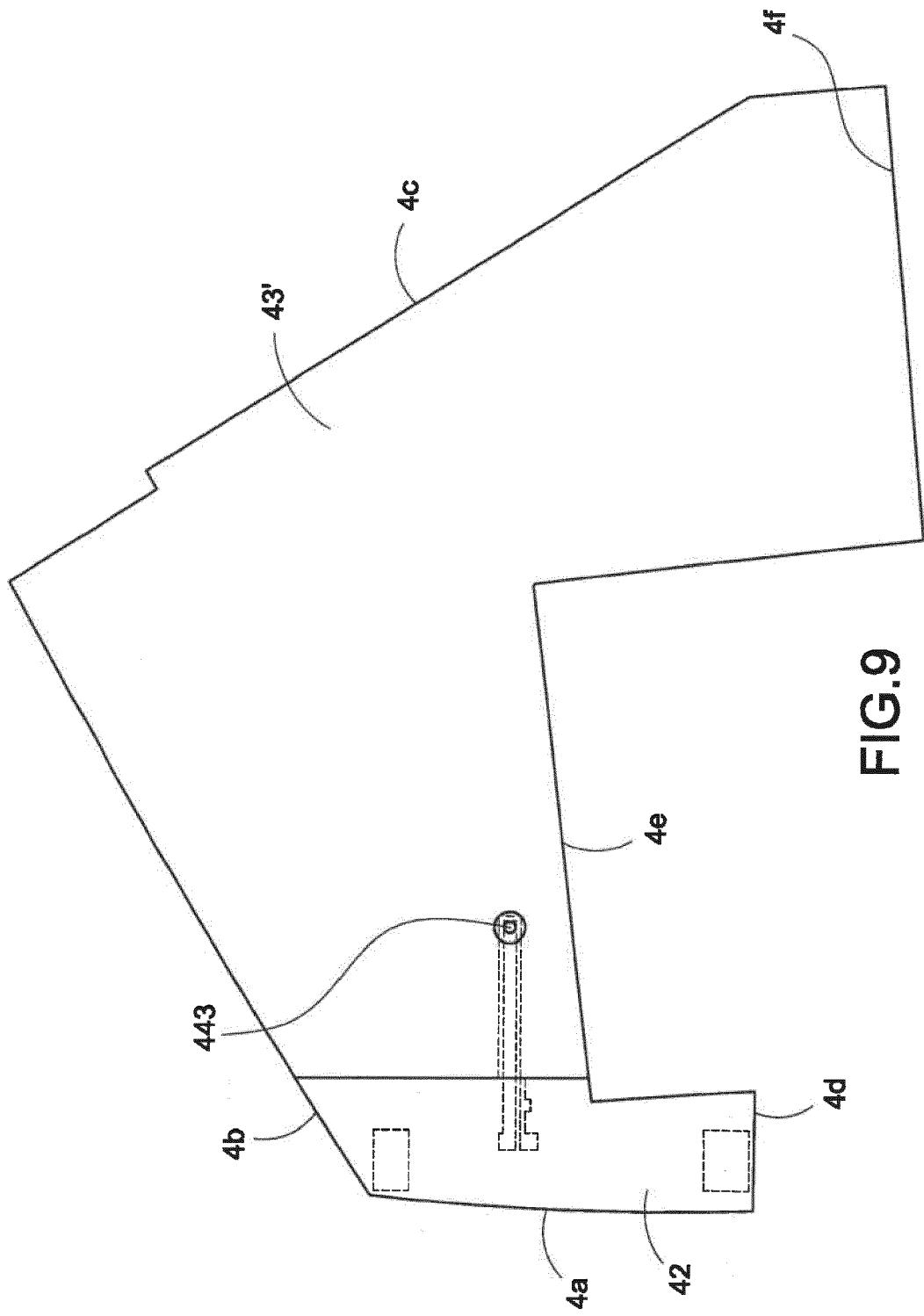


FIG. 9

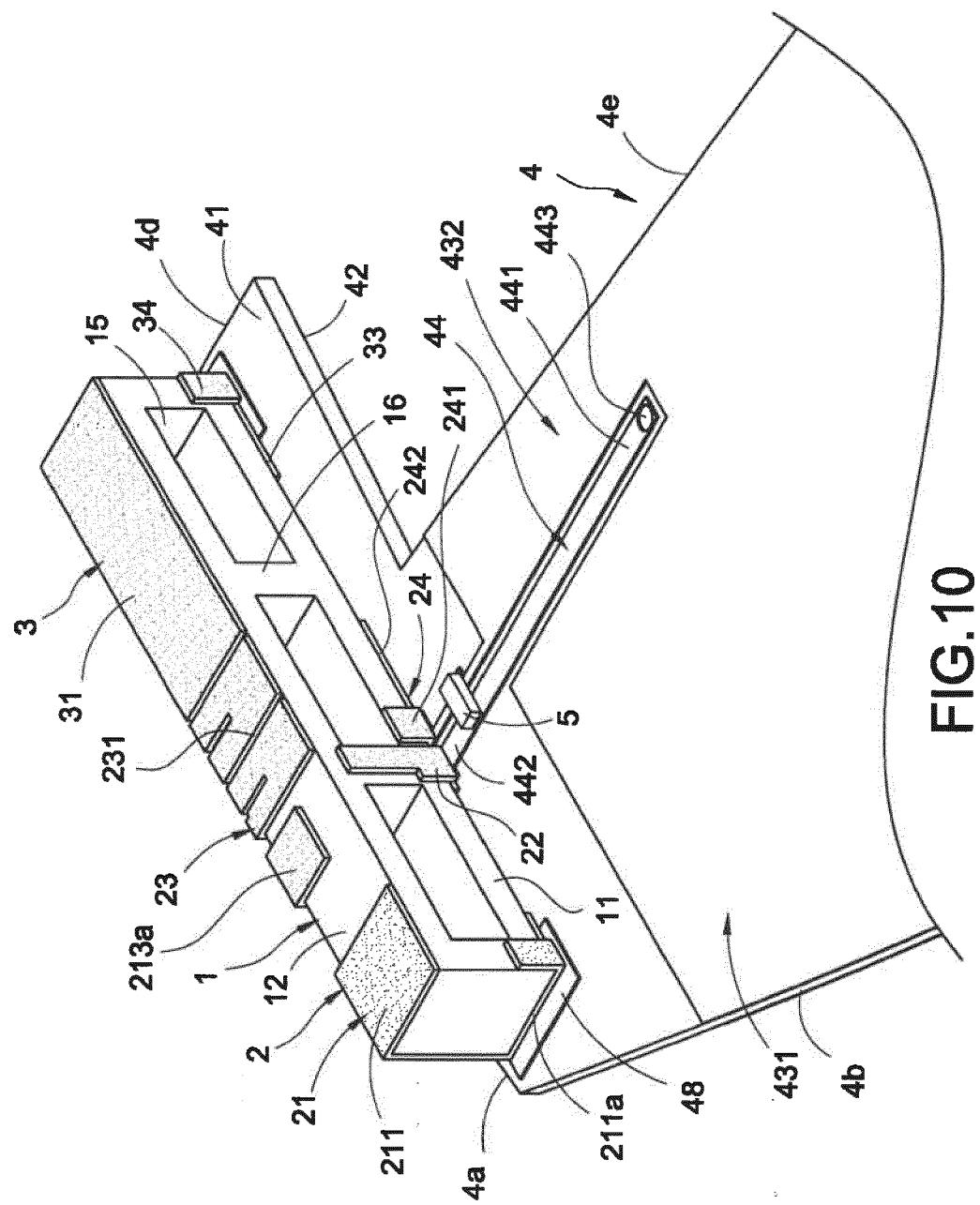


FIG. 10

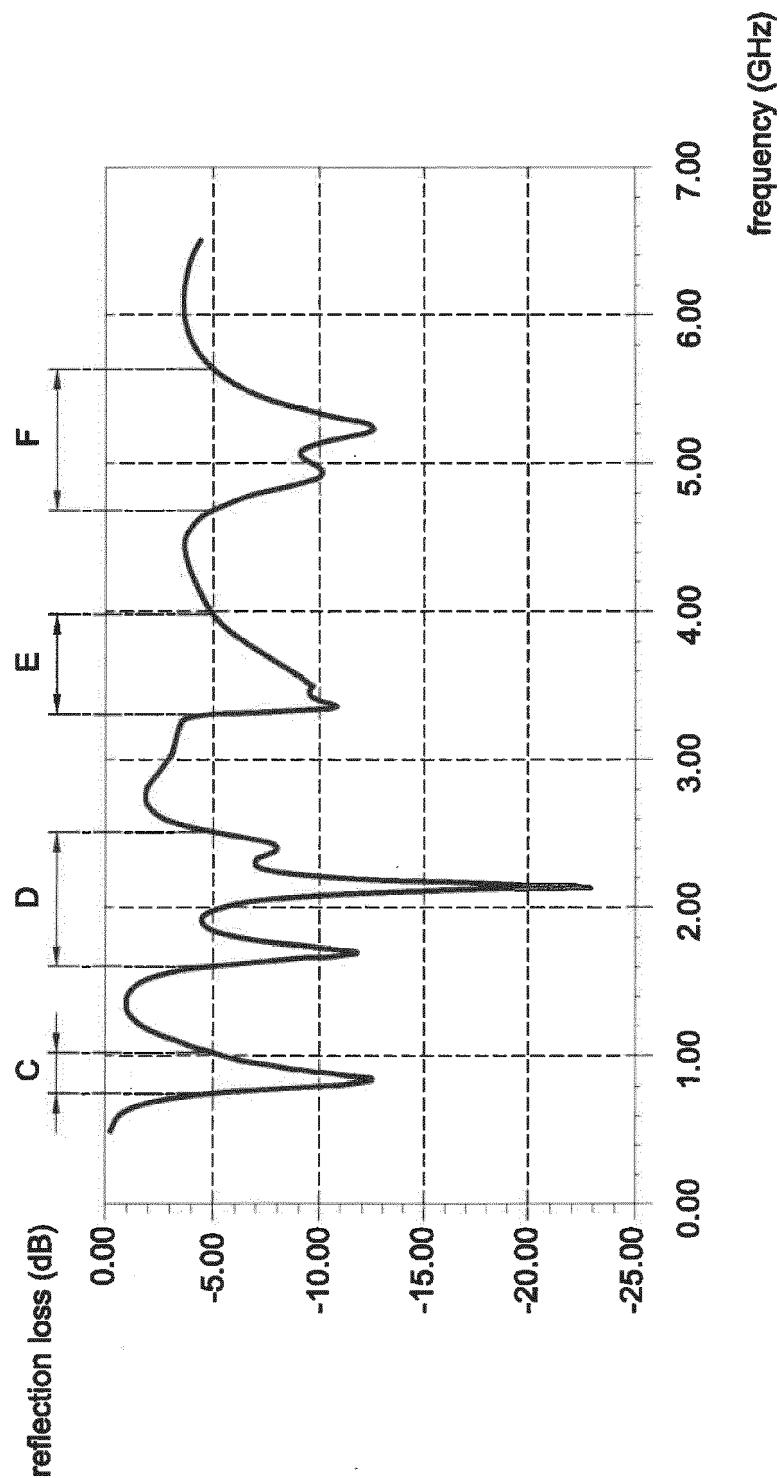


FIG. 11



## EUROPEAN SEARCH REPORT

Application Number

EP 18 18 5525

5

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	WO 2014/058926 A1 (ZUNIGA ELEAZAR [US]) 17 April 2014 (2014-04-17) * figures 1A-1C, 2A-2B, 5A-5B, 6 * * paragraph [0046] * * paragraph [0066] * * paragraph [0095] * * paragraph [0097] - paragraph [0098] * -----	1-5, 9-12 6-8, 13-15	INV. H01Q1/38 H01Q1/48 H01Q5/378
A	US 8 779 988 B2 (YANG TSAI-YI [TW] ET AL) 15 July 2014 (2014-07-15) * figures 1, 6-7 * * column 2, line 29 - line 33 * * column 3, line 26 - line 32 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01Q
The present search report has been drawn up for all claims			
1	Place of search	Date of completion of the search	Examiner
50	The Hague	2 November 2018	Yvonnet, Yannick
CATEGORY OF CITED DOCUMENTS			
55	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 E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	

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ON EUROPEAN PATENT APPLICATION NO.**

EP 18 18 5525

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02-11-2018

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