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(54) Wide-band multiband omnidirectional antenna

(57) An omnidirectional antenna (1) intended for use in two distinct frequency bands and adapted to be connected to a coaxial feed line (3) for a signal, comprising two multifrequency radiating assemblies (5, 6, 35, 36) arranged on top of each other so as to be at the same distance with respect to the connection point between said two radiating assemblies (5, 6, 35, 36) and said coaxial feed line (3), each of said multifrequency radiating assemblies (5, 6, 35, 36) comprising two dipoles (20, 21, 22, 23, 45, 46, 47, 48), each having the possibility to operate at at least two distinct frequency bands, said at least two distinct frequency bands comprising the transmission frequencies of said signal.

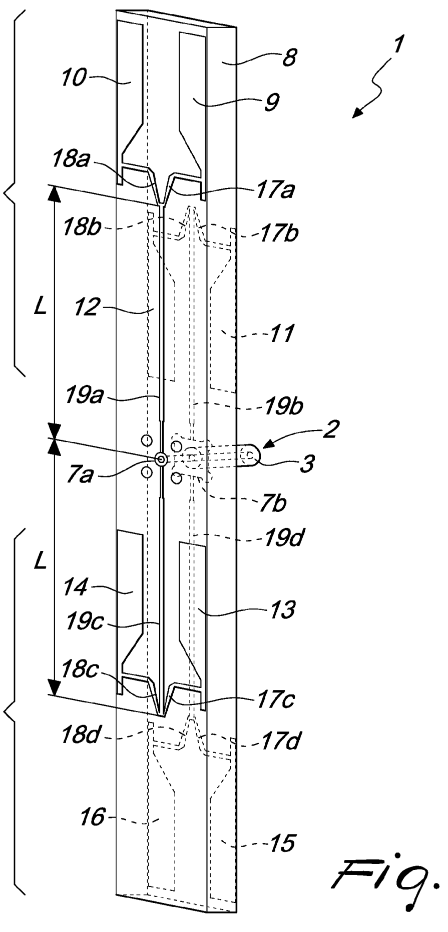

Fig. 1

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Description

[0001] The present invention relates to a wide-band multiband omnidirectional antenna.

[0002] Currently, the development of data transmission and reception technologies and the consequent need for increasingly high performance with reference to the several fields of telecommunications (radio, television, cellular telephony) entail the need for an increase in the frequency bands that are used by the above cited services (consider, for example, the use introduced in recent years of the UMTS band for so-called third-generation cellular telephony services) and of an expansion of the frequency bands already used earlier for the same services or for other services.

[0003] The development of wide-band or multiband products, i.e., products that are capable of covering multiple frequency bands simultaneously and can thus enclose in a single apparatus the functionalities associated with a plurality of distinct frequency bands and therefore can be used for different purposes in relation to the specific service that is needed, is therefore of great commercial interest. In particular, reference is made to products such as antennas for transmission and reception of a plurality of signals at distinct frequencies.

[0004] As is known, wide-band antennas that cover simultaneously two or more frequencies are currently commercially available (see in this regard Italian patent 1.345.159 and in particular Figure 4A).

[0005] These antennas have a structure with a plurality of dipoles (one for each frequency of interest), allowing to cover multiple commercial frequency bands, so that they can be utilized for various communications services in relation to the specific requirements of use.

[0006] However, in the same manner antennas of this type are affected by strong mutual induction currents among the dipoles at the various frequencies. This entails a narrowing of the frequency bands that can be obtained (while maintaining a high gain, of course) and therefore a reduced usability of the antennas in relation to communications services that must cover a certain band.

[0007] The aim of the present invention is to eliminate the drawbacks cited above, by devising a new type of multiband antenna by means of which one obtains increasingly wide bands and which is therefore capable on its own of covering a broader range of frequencies than known antennas and therefore of ensuring coverage of a larger number of services within telecommunications.

[0008] Within this aim, an object of the invention is to provide an antenna that exhibits the highest possible gain.

[0009] Another object of the invention is to provide an antenna that prevents the phenomenon of mutual current induction among the dipoles that constitute the antenna.

[0010] Moreover, an object of the present invention is to reduce mismatchings and eliminate losses linked to currents in phase opposition on the dipoles.

[0011] Another object of the invention is to provide a model of antenna that is highly reliable, relatively easy to provide and at competitive costs.

[0012] This aim, as well as these and other objects that will become better apparent hereinafter, are achieved by an omnidirectional antenna intended for use in two distinct frequency bands and adapted to be connected to a coaxial feed line for a signal, characterized in that it comprises two multifrequency radiating assemblies arranged on top of each other so as to be at the same distance with respect to the connection point between said two radiating assemblies and said coaxial feed line, each of said multifrequency radiating assemblies comprising two dipoles, each having the possibility to operate at two distinct frequency bands, said two distinct frequency bands comprising the transmission frequencies of said signal.

[0013] Further characteristics and advantages of the invention will become better apparent from the description of a preferred but not exclusive embodiment of the antenna according to the invention, illustrated by way of non-limiting example in the accompanying drawings, wherein:

Figure 1 is a perspective view of the antenna according to the invention, in a first embodiment;
Figure 2 is a rear view of the antenna of Figure 1;
Figure 3 is a front view of the antenna of Figure 1;
Figure 4 is a superimposition of the views of Figures 2 and 3;
Figure 4a is a schematic view of a multiband omnidirectional antenna according to the known art;
Figure 5 is a view of the antenna according to the invention covered by an enclosure and provided with bracketing elements for its application to a wall;
Figure 6 plots the pattern of the antenna according to the invention on the plane H and E, for transmission frequencies within the GSM-900 transmission band;
Figure 7 plots the pattern of the antenna according to the invention on the plane H and E, for transmission frequencies within the GSM-1800 transmission band;
Figure 8 plots the pattern of the antenna according to the invention on the plane H and E, for transmission frequencies within the UMTS 2000 transmission band;
Figure 9 is a view given by the overlap of the rear view and of the front view of the antenna according to the invention, in a second embodiment.

[0014] With reference to the figures, the antenna according to the invention, generally designated by the reference numeral 1, comprises, in a first embodiment, a plate made of dielectric material 8 on which there is a first multifrequency radiating assembly 5 and a second multifrequency radiating assembly 6, which are arranged vertically with respect to each other so as to be at the same distance with respect to the central point of the antenna 1, where there is a connector 2, inside which a coaxial feed line runs, said line comprising a coaxial cable 3 for connection between the two radiating assemblies and an apparatus for feeding the antenna.

[0015] The radiating assembly 5 comprises two dipoles, formed by two pairs of conducting elements which are arranged in pairs on the front and rear sides of the antenna 1, i.e., on the opposite faces of the plate of dielectric material 8.

[0016] Such conducting elements have a longitudinal extension with respect to the main axis of the antenna. Substantially, they are therefore arranged vertically.

[0017] In particular, the conducting elements, i.e., the individual antennas 9 and 10, are arranged on the front side of the plate 8. Each one of the conductors is fed by means of a portion of common line 19a which starts from the point 7a at the center of the antenna 1, which represents the point where the coaxial cable 3 touches the front side of the plate 8; the line portion 19a forks proximate to the two conductors 9 and 10 into two separate lines for feeding the individual conductor: the line 17a, which feeds the conductor 9, and the line 18a, which feeds the conductor 10.

[0018] The other two conducting elements 11 and 12 that constitute the radiating assembly 5 are instead arranged on the rear side of the plate 8 and are fed in the same manner by means of a portion of common line 19b which starts from a portion of a printed circuit 7b; in this case also, the portion of common line 19b forks proximate to the two conductors, dividing itself into a portion 17b that feeds the conductor 11 and into a portion 18b that feeds the conductor 12.

[0019] The line portions 19a and 19b have the same length, but the pairs of conductors are arranged so as to face each other in pairs with respect to an ideal horizontal plane, forming a twin electrical line.

[0020] The results is that the point where, in perspective, the lines 17a, 18a, 17b and 18b join, designated by the reference numeral 4 in Figure 4, has a distance L from the center of the antenna 1.

[0021] The dipoles that form the radiating assembly 5 are therefore the dipole 20, which comprises the conducting elements 9 and 11, and the dipole 21, which comprises the conducting elements 10 and 12.

[0022] Substantially, the dipoles 20 and 21 both comprise a conducting element that is arranged on the front side of the plate of dielectric material 8 and another conducting elements that is arranged on the rear side of said plate.

[0023] Likewise, the radiating assembly 6 comprises two dipoles, formed by two pairs of conducting elements that are arranged in pairs on the front and rear sides of the antenna 1, or on the opposite faces of the plate of dielectric material 8.

[0024] Again, the conducting elements have a vertical extension and the main axis of the antenna is likewise vertical.

[0025] In particular, the conducting elements 13 and 14 are arranged on the front side of the plate 8 and are fed by means of a portion of common line 19c that starts from the point 7a at the center of the antenna 1 and forks proximate to the two conductors 13 and 14 into two separate lines for feeding the individual conductor: the line 17c, which feeds the conductor 13, and the line 18c, which feeds the conductor 14.

[0026] The other two conducting elements 15 and 16 that constitute the radiating assembly 6 are instead arranged on the rear side of the plate 8 and are fed by means of a portion of common line 19d that extends from the printed circuit portion 7b; the portion of common line 19d forks again proximate to the two conductors, dividing into a portion 17d, which feeds the conductor 15, and a portion 18d, which feeds the conductor 16.

[0027] Here, too, the line portions 19c and 19d have the same length, but the pairs of conductors are arranged so as to face each other in pairs with respect to an imaginary horizontal plane, albeit on different sides of the plate 8, forming once again a twin electrical line.

[0028] Therefore, the point where, in perspective, the lines 17c, 18c, 17d and 18d join, designated by the reference numeral 24 in Figure 4, has a distance L from the center of the antenna 1.

[0029] The dipoles that form the radiating assembly 6 are therefore the dipole 22, which comprises the conducting elements 13 and 15, and the dipole 23, which comprises the conducting elements 14 and 16.

[0030] Substantially, the dipoles 22 and 23 both comprise a conducting element that is arranged on the front side of the plate of dielectric material 8 and another conducting element that is arranged on the rear side of said plate.

[0031] The two multifrequency radiating assemblies 5 and 6 are connected electrically to each other by means of a contoured line portion 50, which is shown in Figure 5 and represents in practice the perspective superimposition of the portions 19a and 19b in the part of the antenna towards the radiating assembly 5 and 19c and 19d in the part of the antenna towards the radiating assembly 6. The contoured line portion 50 provides the impedance matching for each of the two radiating assemblies.

[0032] All the conducting elements and the line portions cited above are provided by means of copper paths associated with the two opposite surfaces of the plate of dielectric material 8, according to the technological construction known in the production of printed circuits.

[0033] Figure 4a illustrates a configuration according to the known art, wherein the two radiating assemblies 25 and 26 each comprise four dipoles, i.e., eight conducting elements.

[0034] The eight conducting elements are designated by the reference numerals 25a, 25b, 25c, 25d, 25e, 25f, 25g, 25h for the radiating assembly 25 and by the corresponding reference numerals 26a, 26b, 26c, 26d, 26e, 26f, 26g, 26h for the radiating assembly 26.

[0035] Figure 5 illustrates the antenna as it appears to the end user, i.e., surrounded by an enclosure 27 made of plastics, which acts as a covering for protection against atmospheric events and provided with a wall mounting bracket 28.

[0036] Figures 6, 7 and 8 are different patterns of the antenna according to the invention and respectively each figure represents the pattern in the plane H and the pattern in the plane E, said two planes being mutually perpendicular; in particular, the plane E is the one that contains the electrical field vector while the plane H is the one that contains the magnetic field vector.

[0037] Substantially, the plane E for a vertically polarized antenna coincides with the vertical plane, whereas for a horizontally polarized antenna it coincides with the horizontal plane.

[0038] In the case of the antenna according to the invention, since each conducting element is arranged vertically along the direction of the antenna, the situation can be likened to that of a vertically polarized antenna.

[0039] In detail, Figure 6 plots the pattern 29 on the plane H and the pattern 30 on the plane E for signal transmission frequencies comprised in a specific band, designated by GSM-900, around 900 MHz.

[0040] Figure 7 likewise plots the pattern 31 on the plane H and 32 on the plane E, this time for signal transmission frequencies comprised in the GSM-1800 band, around 1800 MHz.

[0041] Finally, Figure 8 plots the pattern 33 on the plane H and 34 on the plane E for signal transmission frequencies comprised in the UMTS 2000 band, around 2000 MHz.

[0042] Figure 9 illustrates instead a second embodiment of the antenna according to the invention, in which for each radiating assembly the two dipoles have different lengths, i.e., the two conducting elements that form a same dipole have a different length with respect to the conducting elements that form the other dipole of the same radiating assembly.

[0043] In particular, within the radiating assembly 35 the conducting elements 37 and 39 that cooperate to form the dipole 25 are shorter than the conducting elements 38 and 40 that cooperate to form the dipole 46.

[0044] Likewise, in the radiating assembly 36 the conducting elements 41 and 43 that cooperate to form the dipole 47 are shorter than the conducting elements 42 and 44 that cooperate to form the dipole 48.

[0045] It should be noted that the lengths of the conducting elements 37 and 39 are the same as those of the conducting elements 41 and 43, and that likewise the lengths of the conducting elements 38 and 40 are the same as those of the conducting elements 42 and 44.

[0046] For the remainder, the structure of the antenna, in constructive terms, is the same already described previously. The difference in the lengths of the dipoles, for each radiating assembly, extends the range of frequency bands that are covered by the antenna, as will be clarified better hereinafter.

[0047] Operation of the antenna according to the invention is as follows.

[0048] The antenna 1 is arranged so that its main axis is in the vertical position and is connected to the coaxial feed line by means of the connector 2 arranged at the center of the antenna, inside which the coaxial line 3 that leads to the feed apparatus of said antenna runs.

[0049] The feed apparatus feeds the antenna 1, and in particular its dipoles, by means of the contoured line portion 50, which subsequently separates, as regards the radiating assembly 5, into the portions 17a, 18a, 17b and 18b, and as regards the radiating assembly 6 into the portions 17c, 18c, 17d and 18d, said portions providing a connection between the dipoles of the same radiating assembly.

[0050] Each one of the dipoles 20, 21, 22 and 23, thanks to its particular geometry, can transmit and receive signals that belong to two distinct frequency bands. Considering between the two a lower frequency band and a higher frequency band, in order to cover the lower frequency band, the dipoles operate according to a first configuration which makes them similar to a classic dipole with a half wavelength $\lambda/2$. To cover the higher frequency band, instead, the dipoles operate according to a second configuration which makes them similar to a dipole with a full wavelength λ, therefore with a greater gain than the first configuration.

[0051] In particular, the antenna 1 can be used for transmission and reception of signals in the bands used by communication technologies for cellular telephone networks such as dual band GSM and UMTS.

[0052] In this regard, the lower frequency band between the two frequency bands covered by a same dipole is the GSM-900 transmission band (around 900 MHz), while the higher frequency band comprises the GSM-1800 transmission band (approximately 1800 MHz) and the UMTS band (approximately 2000 MHz).

[0053] For each one of the two radiating assemblies, in view of the particular constructive shape, the impedance seen at the points 4 and 24, i.e., the points where connection between dipoles of a same radiating assembly and their feeding occur, is substantially identical in both configurations and therefore for both of the frequency bands covered by the antenna. Impedance matching for the antenna 1 is thus provided.

[0054] The new aspect of the invention is that each dipole 20, 21, 22 and 23 is therefore capable of covering, both in transmission and in reception, two separate frequency bands ("dual band" dipole); this differs from the known configuration shown in Figure 4a, since the latter is unable to cover effectively frequency bands that are close to each other (GSM 1800 and UMTS 2000 in the example considered). Indeed, even supposing that a further dipole calibrated to the UMTS 2000 frequency (GSM 900 and 1800 are already present) were added, the currents generated by mutual induction on the dipoles would act destructively on the bandwidth and on the quantity of signal emitted to such an extent as to make it useless to add the dipole.

[0055] The antenna shown in Figure 1 overcomes this problem by using a single dipole. This entails the absence of mutual induction, which otherwise would be present, and therefore the possibility to widen the band so much as to be able to comprise multiple services simultaneously (for example, GSM 1800 and UMTS 2000 in the case considered).

[0056] The pattern 29 on the plane H, shown in Figure 6 and referred to the case in which the antenna 1 operates in the GSM-900 band, clearly shows the omnidirectionality of said antenna, i.e., shows that the antenna has a substantially identical directivity in all directions, since the level of gain in dB is identical at all angles. The plane H is the one arranged at right angles to the direction of extension of the antenna; in other words, assuming that the antenna is arranged vertically, the plane H is a horizontal plane. For the sake of completeness, the pattern 30 on the plane E perpendicular to the plane H for the same GSM-900 band is also shown.

[0057] Figure 7 plots the pattern 31 on the plane H and 32 on the plane E, this time referred to the operation of the antenna 1 in the GSM-1800 band, around 1800 MHz. The results can be considered identical to the previous ones and thus confirm the omnidirectionality of the antenna, although the pattern 31 has a slightly irregular shape. The same applies to the patterns 33 on the plane H and 34 on the plane E, which refer to the operation of the antenna 1 in the UMTS band, around 2000 MHz.

[0058] In a second embodiment according to the invention, shown in Figure 9, inside each radiating assembly the dipoles have different lengths; for the radiating assembly 35, in fact, the conducting elements 37 and 39 that constitutes the dipole 45 are shorter than the conducting elements 38 and 40 that constitute the dipole 46. The same can be said, in the radiating assembly 36, for the conducting elements 41 and 43 that constitute the dipole 47, which is shorter than the conducting elements 42 and 44 that constitute the dipole 48.

[0059] This allows a further improvement with respect to the first embodiment of the antenna 1, since it allows the antenna to cover four distinct frequency bands instead of just two.

[0060] In practice it has been found that the antenna according to the invention fully achieves the intended aim, since it allows to cover two or more distinct frequency bands that are distinctly larger than known solutions.

[0061] The presence of a single dual-band radiating element as a replacement of two or more single-frequency dipoles in fact prevents the formation of mutual induction between the dipoles; accordingly, wider frequency bands and higher maximum gains are achieved, since mismatches are reduced and losses linked to any currents in phase opposition that are present on the dipoles are eliminated.

[0062] Finally, the antenna, covered by the enclosure made of plastics, can be protected easily against atmospheric events or any damage caused by direct exposure to the air; moreover, the fixing bracket makes it particularly easy to install the antenna on a wall of a building or wherever one wishes.

[0063] Although the antenna according to the invention has been conceived in particular to cover the frequency bands used by third-generation cellular telephony services, such as dual-band GSM and UMTS, it can nonetheless be used more generally to cover two or more distinct frequency bands so as to ensure the provision of a generic service for the transmission and reception of signals in telecommunications.

[0064] The invention thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the appended claims; all the details may further be replaced with other technically equivalent elements.

[0065] In practice, the materials used, as well as the dimensions, may be any according to requirements and to the state of the art.

[0066] The disclosures in Italian Patent Application No. MI2010A000177 from which this application claims priority are incorporated herein by reference.

[0067] Where technical features mentioned in any claim are followed by reference signs, those reference signs have been included for the sole purpose of increasing the intelligibility of the claims and accordingly, such reference signs do not have any limiting effect on the interpretation of each element identified by way of example by such reference signs.

Claims

1. An omnidirectional antenna (1) intended for use in two distinct frequency bands and adapted to be connected to a coaxial feed line (3) for a signal, **characterized in that** it comprises two multifrequency radiating assemblies (5, 6, 35, 36) arranged on top of each other so as to be at the same distance with respect to the connection point between said two radiating assemblies (5, 6, 35, 36) and said coaxial feed line (3), each of said multifrequency radiating assemblies (5, 6, 35, 36) comprising two dipoles (20, 21, 22, 23, 45, 46, 47, 48), each having the possibility to operate at at least two distinct frequency bands, said at least two distinct frequency bands comprising the transmission frequencies of said signal.

2. The antenna according to claim 1, **characterized in that** said dipoles (20, 21, 22, 23, 45, 46, 47, 48) operating at at least two distinct frequency bands comprise conducting elements (9, 10, 11, 12, 13, 14, 15, 16, 37, 38, 39, 40, 41, 42, 43, 44) which extend longitudinally with respect to the main axis of said antenna.

3. The antenna according to claim 1, **characterized in that** each of said dipoles (20, 21, 22, 23, 45, 46, 47, 48) comprises a first dipole configuration with a half-wavelength $\lambda/2$ for the lowest frequency band between said at least two distinct frequency bands and

a second dipole configuration with a wavelength λ for the highest frequency band between said at least two distinct frequency bands.

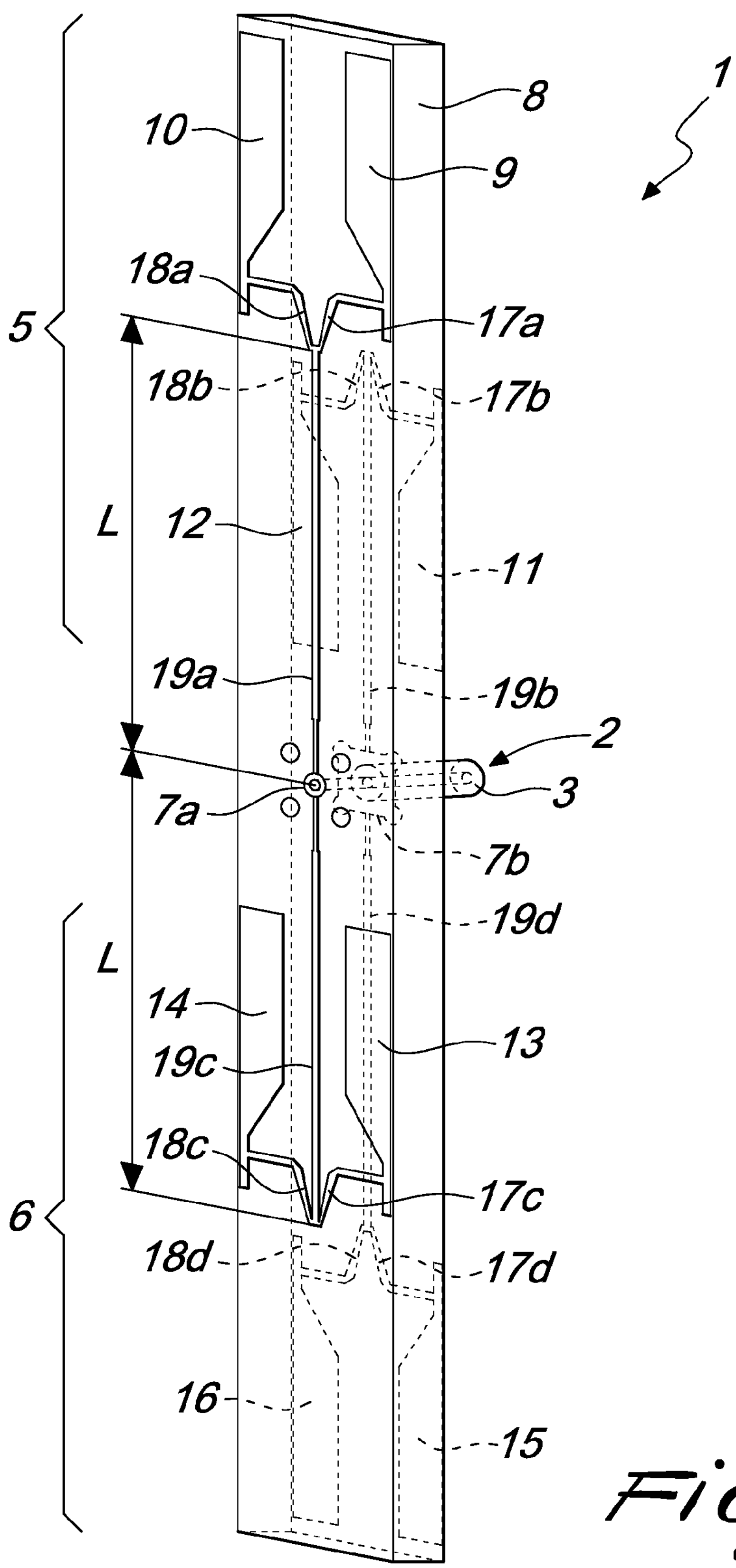
4. The antenna according to claim 3, **characterized in that** said lowest frequency band between said at least two distinct frequency bands is the GSM-900 transmission band.

5. The antenna according to claim 3, **characterized in that** said highest frequency band between said at least two distinct frequency bands is the GSM-1800 and UMTS-2000 transmission band.

6. The antenna according to claim 1, **characterized in that** said multifrequency radiating assemblies (5, 6, 35, 36) are electrically connected to each other by means of a shaped line portion (50) adapted to provide impedance matching for each of said radiating assemblies (5, 6, 35, 36).

7. The antenna according to claim 1, **characterized in that** said multifrequency radiating assemblies (5, 6, 35, 36) comprise copper paths associated with the opposite surfaces of a supporting plate made of dielectric material (8).

8. The antenna according to claim 1, **characterized in that** each of said multifrequency radiating assemblies (35, 36) comprises two dipoles of different length (45, 46, 47, 48), each being able to operate at two frequency bands which are distinct and different for each dipole.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18b
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12
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19b
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7b
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L
14
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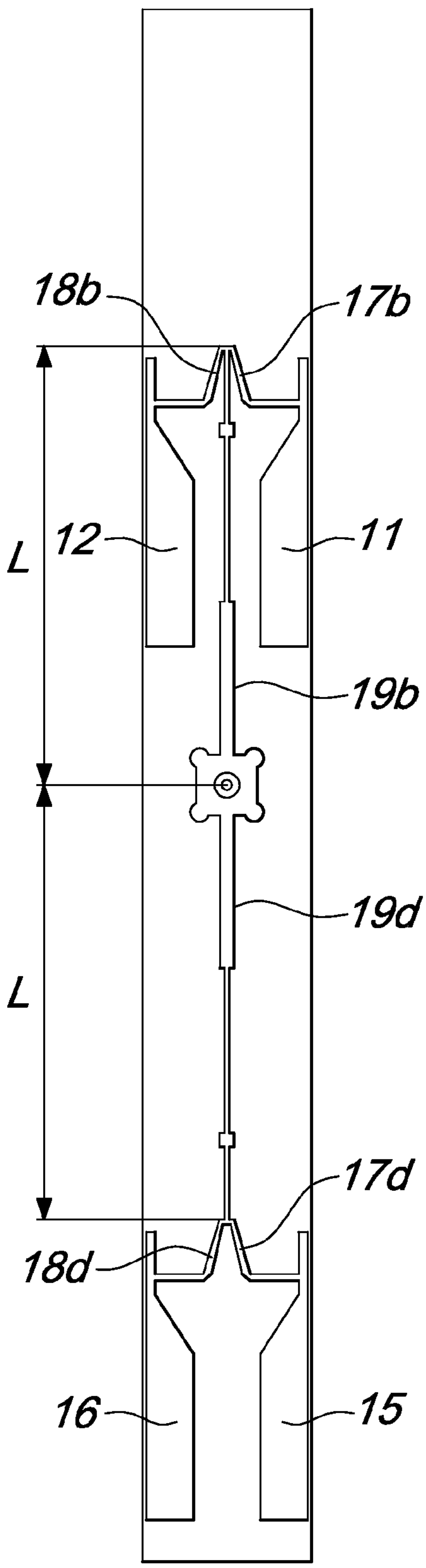
19c
18c
17c
6
18d
17d
16
15

Fig. 1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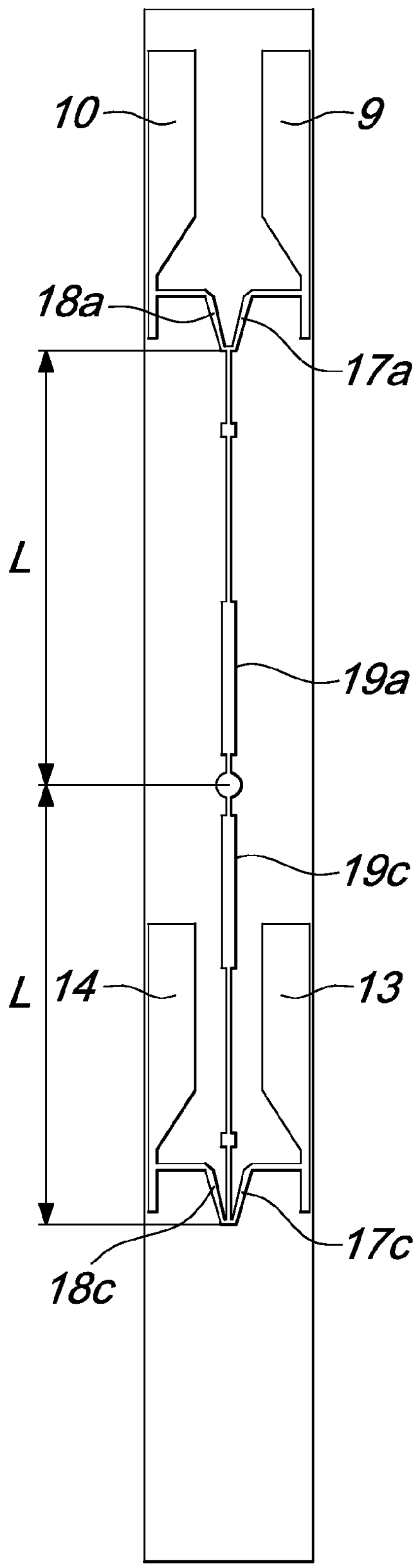
L
12
11
19b
19d
L
17d
18d
16
15

Fig. 2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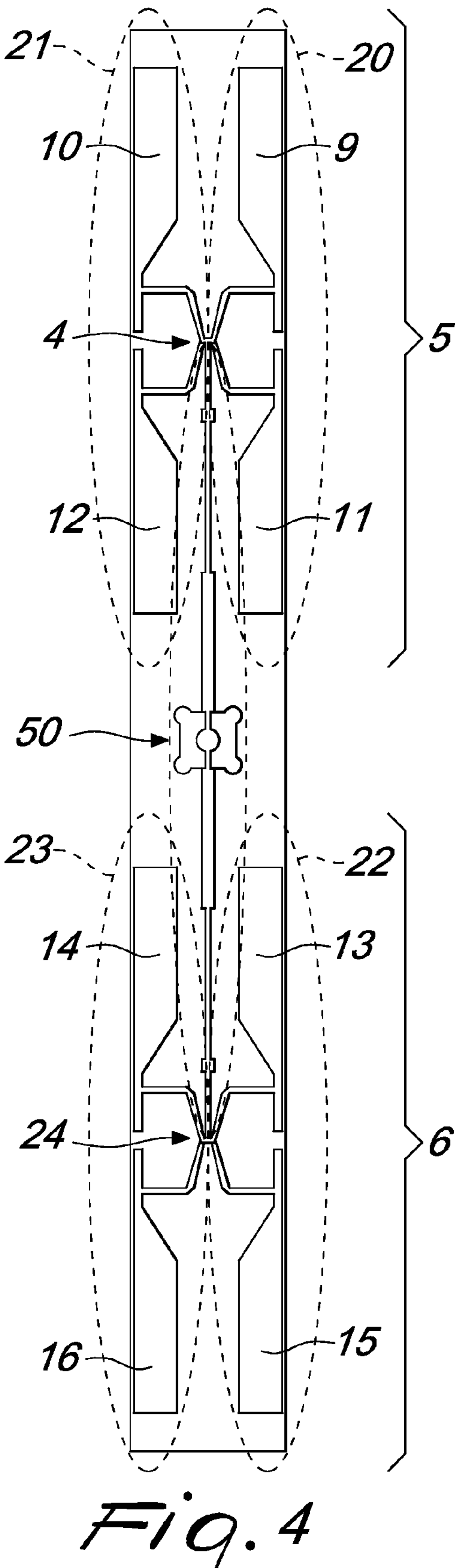
17a
L
19a
19c
L
14
13
17c
18c

Fig. 3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15

Fig. 4

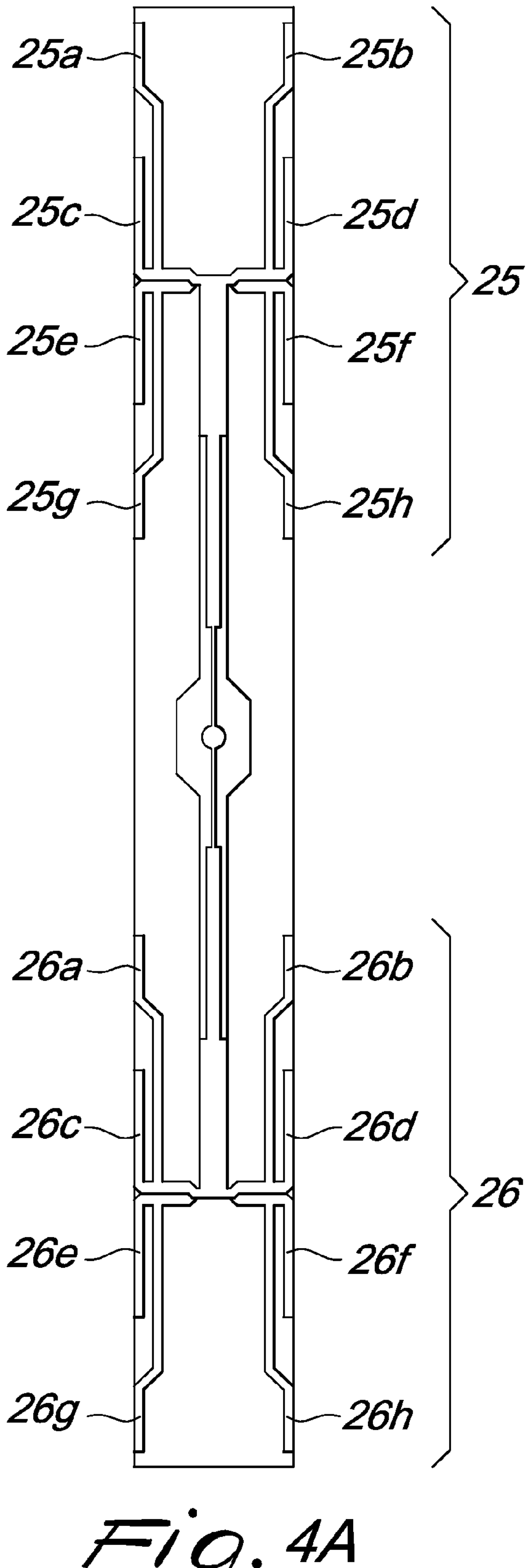
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Fig. 4A

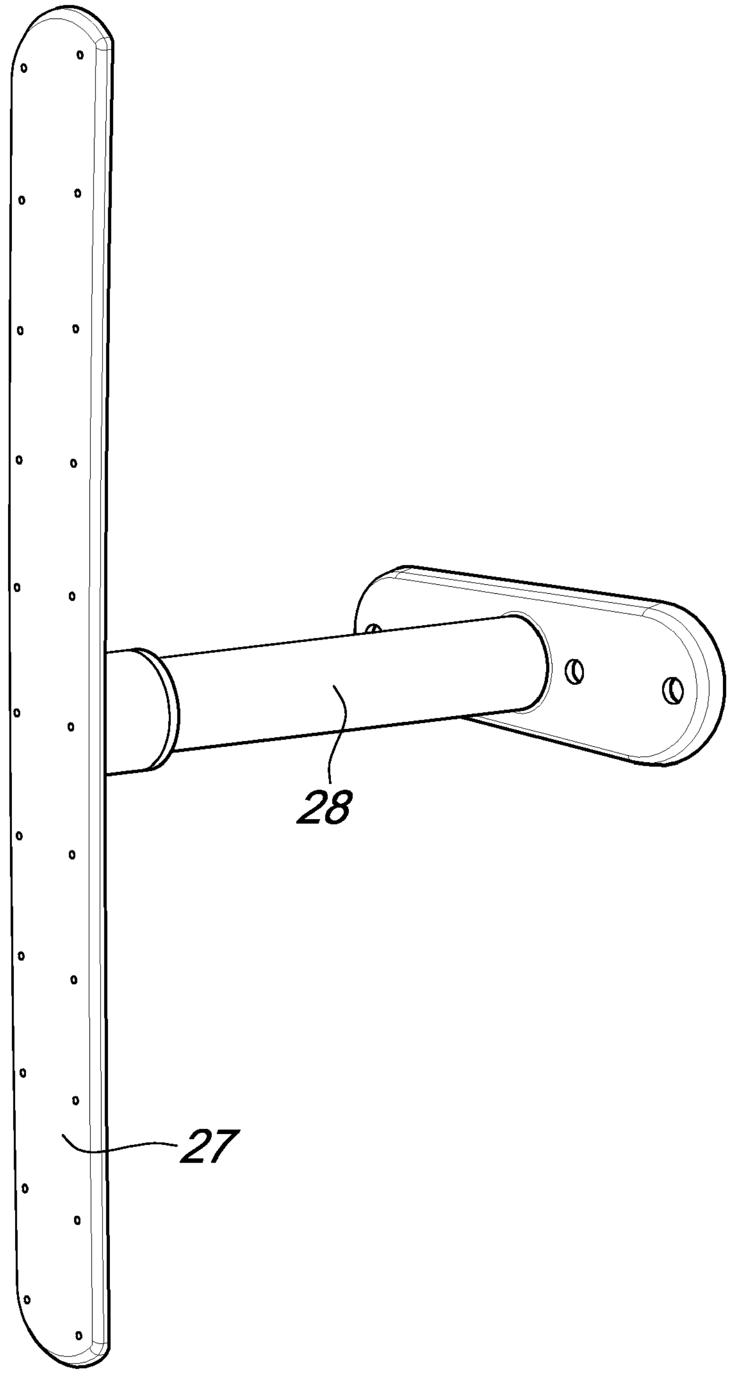

Fig. 5

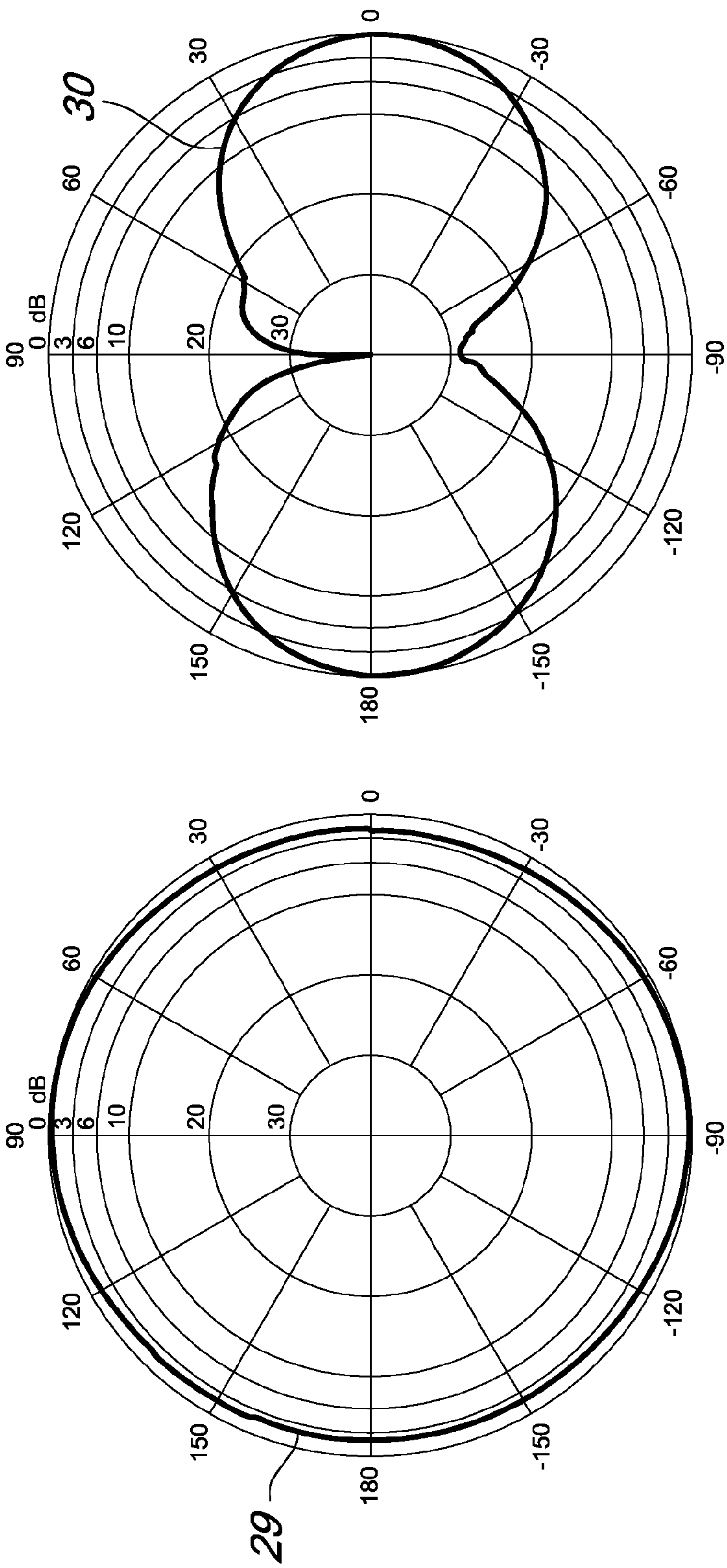

Fig. 6

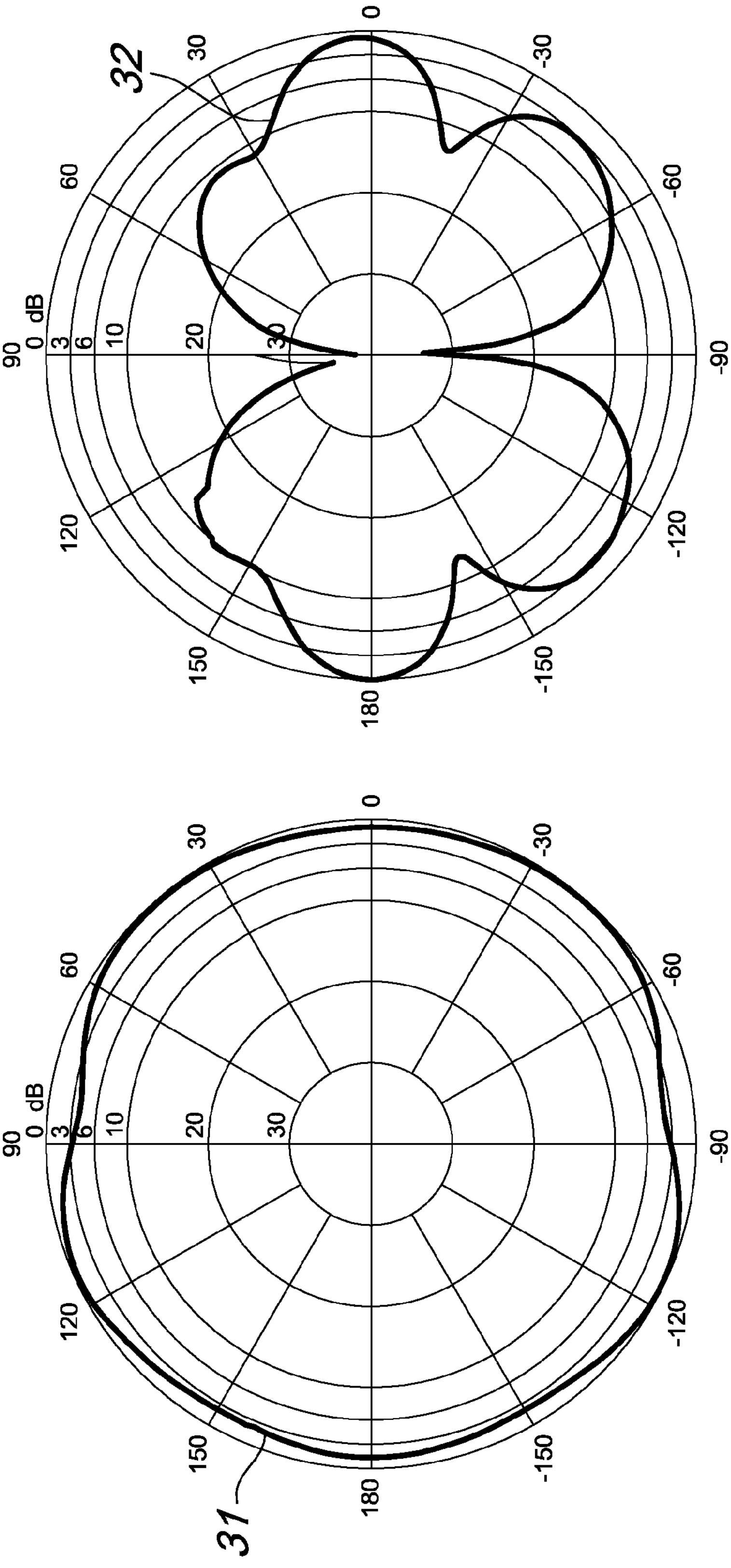

Fig. 7

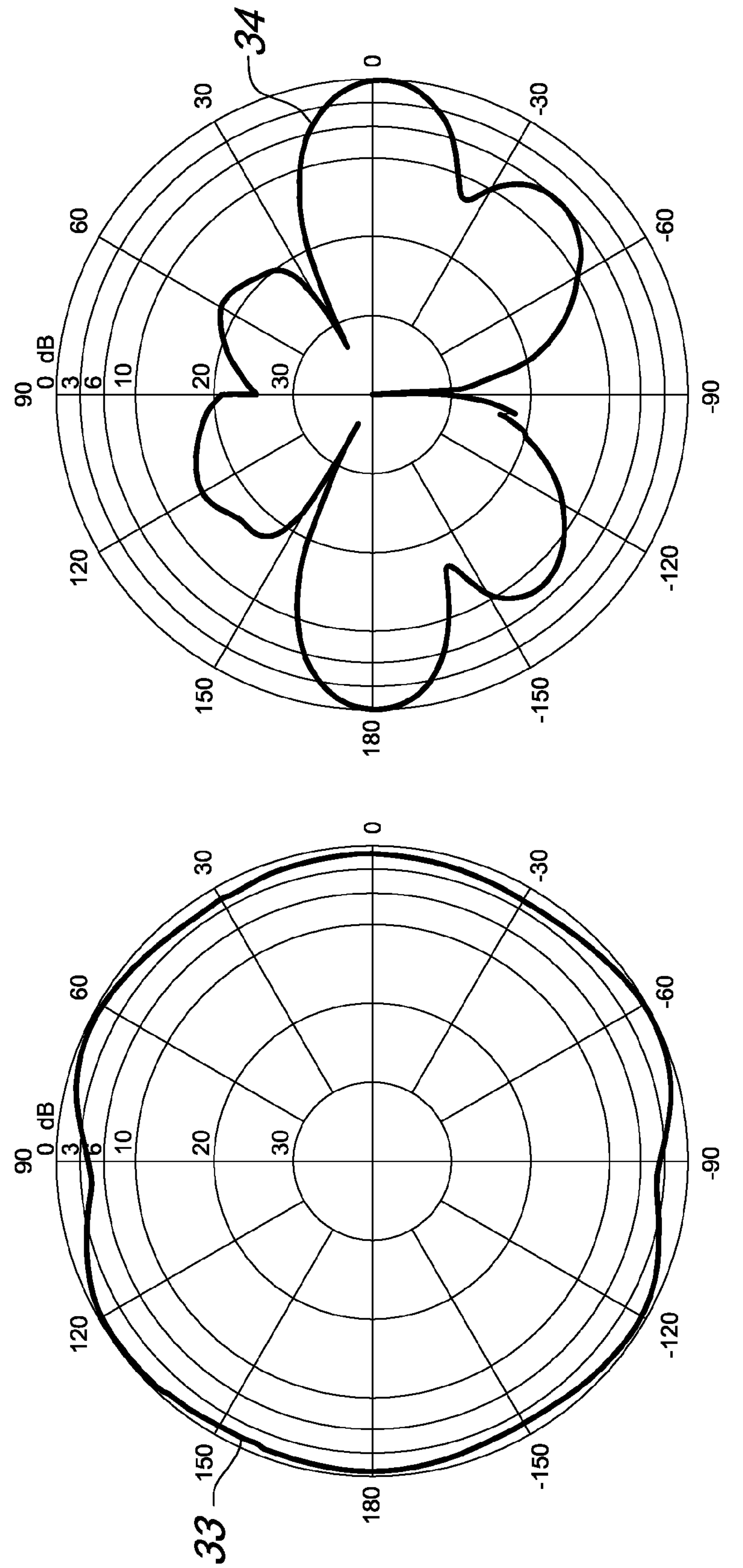

Fig. 8

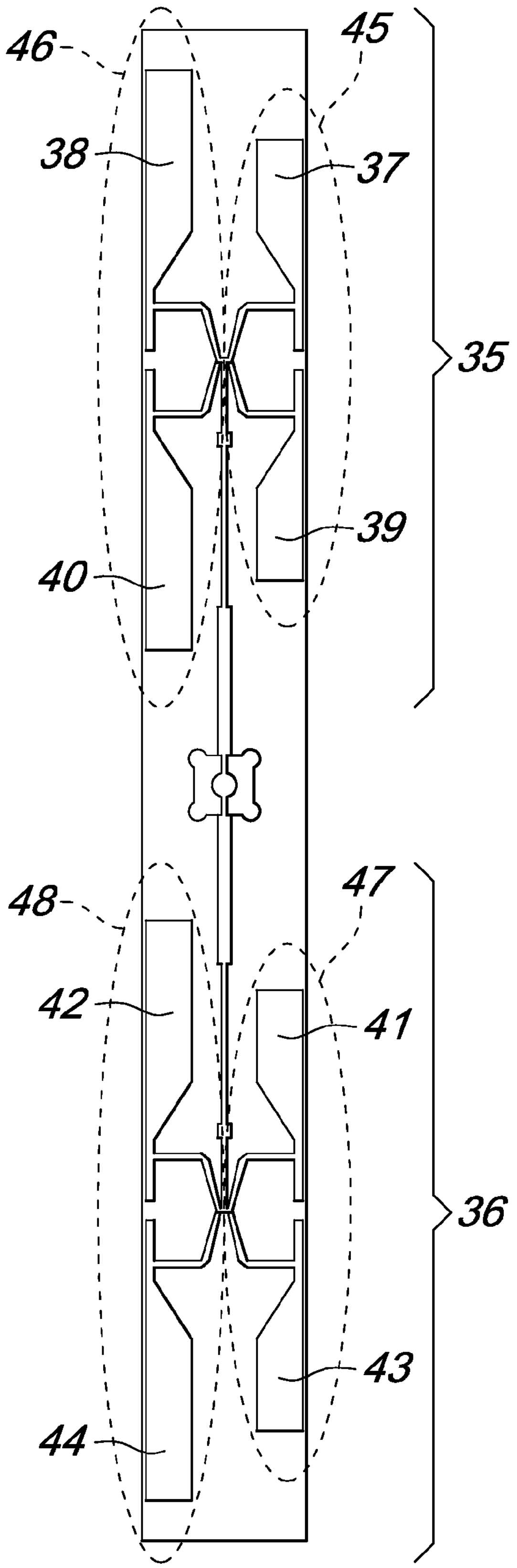

Fig. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 10 16 2338

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2008/074340 A1 (SONG JIA-JIU [TW] ET AL) 27 March 2008 (2008-03-27) * paragraph [0049] - paragraph [0065]; figure 2G * -----	1-7 8	INV. H01Q5/00 H01Q9/28 H01Q21/06
X	US 2004/145532 A1 (CHEN I-FONG [TW] ET AL) 29 July 2004 (2004-07-29) * paragraph [0022] - paragraph [0023]; figure 3 * -----	1-7	
X	WO 03/010854 A1 (ATHEROS COMM INC [US]) 6 February 2003 (2003-02-06) * page 8, line 21 - page 10, line 6; figures 4-6 * -----	1-7	
Y	WO 2008/131157 A1 (SKYCROSS INC [US]; MONTGOMERY MARK T [US]; CAIMI FRANK M [US]; KISHLER) 30 October 2008 (2008-10-30) * paragraph [0092]; figure 8 * * paragraph [0084] * -----	8	TECHNICAL FIELDS SEARCHED (IPC)
A	US 2004/183727 A1 (CHOI JONG-IN [KR]) 23 September 2004 (2004-09-23) * abstract * -----	1-8	H01Q

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	30 September 2010	Kaleve, Abraham

CATEGORY OF CITED DOCUMENTS

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30-09-2010

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