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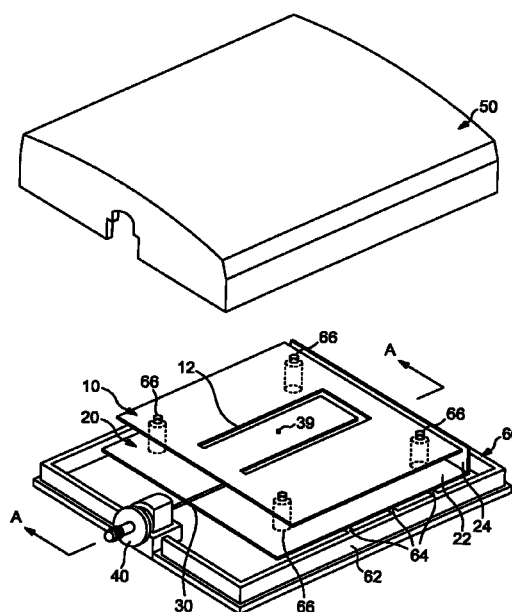
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(54) **Patch antenna having flexed ground plate**

(57) A patch antenna which shows a wide band-width and maintains a high radiation efficiency without increasing the size thereof. The patch antenna comprises a radiating plate (10), a ground plate (20), and means (30) for feeding the radiating plate (10). The ground plate (20) has a base plane (22) and at least one vertical lip (24) extended perpendicularly from the base plane (22) to have a "L"-shaped or "U"-shaped cross section.

**FIG. 1**



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## Description

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

[0001] The present invention relates to an antenna, and more particularly, to a patch antenna typically used for mobile communications equipment. This application for the patch antenna is based on Korean patent application No. 1998-37870, which is incorporated by reference herein for all purposes.

#### 2. Description of the Related Art

[0002] A patch antenna is light in its weight and has a thin cross section so as to be fixed easily to the roof or window of a car or the wall of a building. Thus, the patch antenna is preferred for wide radio applications including military purposes and commercial purposes, e.g., missiles, battlefield surveillance systems, telemetry systems, and aircraft or satellite communications. However, the patch antenna has a disadvantage in that it shows a narrow bandwidth, which typically ranges between 1 and 2%. Accordingly, it has been desired to develop an antenna which shows a wide bandwidth while maintaining the small size thereof.

[0003] Several approaches have been made to increase the bandwidth of the patch antenna but each attempt may introduce some new disadvantage. For example, increasing the height of a radiating plate with respect to a ground plate does increase the bandwidth but it also increases the excitation of surface waves and radiation from a feed line, both undesirable side effects. Another approach utilizes multiple patches which are stacked vertically at different levels with respect to a substrate. This approach directed to the multilayer patch configuration increases fabrication difficulties, and hence the cost of the antenna. Also, in both of the above approaches, the total thickness of the antenna is increased which reduces its utility in low profile operations. Yet another approach for increasing the bandwidth of the patch antenna involves the design of an impedance matching circuit for the patch antenna. In such an approach, the impedance matching circuit is designed so as to reduce the reactance component of the input impedance of the antenna. However, such an approach increases the antenna size and reduces the radiation efficiency.

### SUMMARY OF THE INVENTION

[0004] The object of the present invention is to provide a patch antenna which shows a wide bandwidth and maintains a high radiation efficiency without increasing the size thereof.

[0005] The patch antenna for achieving the above object comprises a radiating plate, a ground plate, and

means for feeding the radiating plate. The ground plate has a base plane and at least one vertical lip extended perpendicularly from the base plane to have an "L"-shaped or "U"-shaped cross section. In such a structure, a capacitive coupling is induced in the space between the radiating plate and the ground plate in the vicinity of the vertical lip, so that a wideband impedance matching and an increased forward-to-back ratio are obtained.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0006] The above objectives and advantages of the present invention will become more apparent by describing in detail preferred embodiments thereof with reference to the attached drawings in which:

FIG. 1 illustrates an embodiment of a patch antenna assembly according to the present invention;

FIG. 2 illustrates a cross-sectional view along line A-A of the patch antenna assembly of FIG. 1;

FIG. 3 is a graph showing the experimental measurement of a standing wave ratio for the patch antenna assembly of FIGS. 1 and 2;

FIG. 4 shows an E-plane radiation pattern for the patch antenna assembly of FIGS. 1 and 2;

FIG. 5 shows a H-plane radiation pattern for the patch antenna assembly of FIGS. 1 and 2;

FIG. 6 illustrates another embodiment of a patch antenna assembly according to the present invention; and

FIG. 7 illustrates a cross-sectional view along line B-B of the patch antenna of FIG. 6.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0007] Referring to FIGS. 1 and 2, a patch antenna assembly in a preferred embodiment includes a patch antenna element and a housing for accommodating the patch antenna element. The patch antenna element includes a radiating plate 10, a ground plate 20, and a coaxial cable 30 for feeding signals to the radiating plate 10.

[0008] The housing consists of a top housing 50 and a bottom housing 60. The bottom housing 60 includes, on its top surface, an outer wall 62, protrusions 64 extending inwards from the outer wall 62 for supporting the ground plate 20, and fingers 66 for securing the radiating plate 10. Even though not being illustrated in the figures, four protrusions are formed on the inner surface of the wall of the top housing 50 and four recesses are formed correspondingly on the outer surface of the outer wall 62 of the bottom housing 60, so that the top housing 50 can be secured on the bottom housing 60. The housing is preferably made of plastic dielectric material having sufficient physical strength yet minimiz-

ing the reflection of the electromagnetic wave transmitted from or received by the patch antenna element.

**[0009]** The radiating plate 10 and the ground plate 20 may be made of conductive material such as a copper or aluminum sheet. The radiating plate 10 is rectangular-shaped and has a slit 12 having a "U"-shape and penetrating itself. The radiating plate 10 has a hole in its center for receiving a probe 39, i.e., the end of the center conductor of the coaxial cable 30, and holes near its corners for receiving the top end of the fingers 66. Meanwhile, the ground plate 20 has a base plane 22 and a vertical lip 24 extending perpendicularly from an edge of the base plane 22 so as to have an "L"-shaped cross section. Also, the ground plate 20 has holes so that the fingers 66 penetrate the plate.

**[0010]** The coaxial cable 30 includes a center conductor 32, an insulating layer 34 surrounding the center conductor 32, and an outer conductor 36 surrounding the insulating layer 34. The coaxial cable 30 is not sheathed and thus uninsulated in its outer surface so that the outer conductor 36 of the cable 30 directly contacts the ground plate 20. Meanwhile, a coaxial connector 38 for connecting the patch antenna assembly to an external circuit is disposed at an end of the coaxial cable 30. The other end of the cable 30 is flexed upwards by 90°. Here, the outer conductor 36 is stripped off at the vertical portion of the cable 30 flexed upwards.

**[0011]** The patch antenna assembly is assembled as follows. The ground plate 20 is disposed on the protrusions 64 while the fingers 66 being inserted into the holes of the ground plate 20. Next, the fitting portion of the coaxial connector 38 is disposed in a mating groove 62 of the bottom housing 60, and the outer conductor 36 of the coaxial cable 30 is fixed, preferably by soldering, on the ground plate 20. Subsequently, the radiating plate 10 is disposed on the top end of the fingers 66 while the probe 39 of the coaxial cable 30 being inserted to the center hole of the radiating plate 10. The probe 39 is soldered in the center hole of the radiating plate 10, so that the radiating plate 10 is electrically connected to the center conductor 32 of the coaxial cable 30 while being secured in parallel with the ground plate 20. Finally, the top housing 50 is secured on the bottom housing 60 by engaging four not shown protrusions on the inner surface of the wall of the top housing 50 and four not shown recesses on the outer surface of the bottom housing 60.

**[0012]** In the patch antenna assembly of FIGS. 1 and 2, the radiating plate 10 is parallel to, but separated from the ground plate 20 by the coaxial cable 30 and the fingers 66. Also, the outer conductor 36 of the coaxial cable 30 terminates on the ground plate 20 and the center conductor 32 terminates on the radiating plate 10. Thus, the radiating plate 10 is fed from the rear using the center conductor 32 of the coaxial cable 30.

**[0013]** Meanwhile, the vertical lip 24 extending from the edge of the base plane 22 changes the electromag-

netic field distribution in the space between the radiating plate 10 and the ground plate 20 in the vicinity of the vertical lip 24. Such a change in the electromagnetic field distribution increases a distributed capacitance between the radiating plate 10 and the ground plate 20. The increased distributed capacitance compensates for the inductive reactance induced in the coaxial cable 30, which allows a wideband impedance matching and expands the beam width of the main lobe of the radiated wave.

**[0014]** Also, the magnitude of the induced capacitance may be adjusted by varying the height of the vertical lip 24 and the distance between the edge of the radiating plate 10 and the vertical lip 24. That is, if the distance between the edge of the radiating plate 10 and the vertical lip 24 is getting smaller, the induced capacitance is getting larger and the resonance frequency moves toward a lower band. Thus, it is possible to reduce the dimension of the radiating plate 10 and the overall size of the antenna. For example, the length of the radiating plate 10 may be determined to be smaller than  $\lambda/2$ , where  $\lambda$  is the operating wavelength of the antenna assembly.

**[0015]** On the other hand, it is well known in the art that a larger ground plate is preferable in a directional antenna in order to enhance the front-to-back ratio of the antenna. The larger ground plate, however, is disadvantageous in that it also increases the dimension and weight of the antenna. In the patch antenna according to the present embodiment, the vertical lip 24 of the ground plate 20 reduces the portion of the wave which radiates backward from the radiating plate 10. Accordingly, it is possible to enhance the front-to-back ratio while reducing the horizontal dimension of the ground plate 20 compared with those of prior art.

**[0016]** FIG. 3 shows the experimental measurement of a standing wave ratio for the patch antenna assembly of FIGS. 1 and 2. Standing wave ratios were calculated based on scattering (S) parameters measured at the input terminal of the coaxial connector 40. Standing wave ratios at 824, 849, 869 and 894 MHz were 1.23, 1.15, 1.26, and 1.18, respectively. As shown in FIG. 3, the standing wave ratio for the patch antenna assembly of FIGS. 1 and 2 maintains low value over a wide band extending more than 100 MHz.

**[0017]** FIGS. 4 and 5 show E-plane and H-plane radiation patterns, respectively, at 849 MHz for the patch antenna assembly of FIGS. 1 and 2. The antenna radiation patterns show that most of the power is radiated to the front direction of the radiating plate and reflect the high front-to-back ratio of the patch antenna according to the present invention. As shown in FIGS. 4 and 5, the maximum E-plane gain is 7.54 dB and the maximum H-plane gain is 7.80 dB. The beam width at 3 dB half point is 82.32 degrees in the E-plane and 84.05 degrees in the H-plane.

**[0018]** FIGS. 6 and 7 illustrate another embodiment of a patch antenna assembly according to the present

invention. In the patch antenna assembly shown in FIGS. 6 and 7, the ground plate 70 is flexed upwards at two edges opposite to each other so as to have a "U"-shaped cross section. Accordingly, the ground plate 70 includes a base plane 72 and a first vertical lip 74 extending perpendicularly from an edge of the base plane 72, and a second vertical lip 76 extending perpendicularly from another edge of the base plane 72 and being parallel to the first vertical lip 74. The other features of the patch antenna assembly of FIGS. 6 and 7 are similar to those of the patch antenna assembly of FIGS. 1 and 2, and thus detailed description thereof will be omitted.

**[0019]** Although the present invention has been described in detail above, it should be understood that the foregoing description is illustrative and not restrictive. Those of ordinary skill in the art will appreciate that many obvious modifications can be made to the invention without departing from its spirit or essential characteristics. For example, even though any dielectric material other than air is not filled between the radiating plate and the ground plate in the preferred embodiments, a dielectric layer such as a Teflon fiberglass layer and a ceramic layer may be inserted between the radiating plate and the ground plate alternatively. Accordingly, the scope of the invention should be interpreted in the light of the following appended claims.

## Claims

1. A patch antenna comprising:
  - a radiating plate (10);
  - a ground plate (20) comprising a base plane (22) having a first and a second edges and being parallel to but separated from said radiating plate (10), and a first vertical lip (24) extending perpendicularly from said first edge of said base plane (22); and
  - means (30) for feeding said radiating plate (10).
2. The patch antenna as claimed in claim 1, wherein said base plane (22) of said ground plate (20) has a rectangular shape.
3. The patch antenna as claimed in claim 1, wherein said radiating plate (10) has a slit (12) having a "U"-shape.
4. The patch antenna as claimed in claim 1, further comprising:
  - means (66) for supporting said radiating plate (10) so that said radiating plate (10) is maintained rigidly being parallel to but separated from said ground plate (20).
5. The patch antenna as claimed in claim 4, wherein said patch antenna is installed in a housing having an inner bottom surface and at least one fingers fixed on the inner bottom surface, said supporting means (66) being said at least one fingers.
6. The patch antenna as claimed in claim 1, further comprising:
  - an dielectric layer, disposed between said radiating plate (10) and said ground plate (20), said dielectric layer made of a dielectric material selected from the group consisting of ceramic and Teflon fiberglass.
7. The patch antenna as claimed in claim 1, wherein said radiating plate (10) is separated from said ground plate (20) by a predetermined distance so as to perform a wideband impedance matching and coincide a resonant frequency of said patch antenna substantially to an operating frequency.
8. The patch antenna as claimed in claim 1, wherein the height of said first vertical lip (24) and the distance between said radiating plate (10) and said first vertical lip (24) is determined in such a manner that a desired beam width is obtained.
9. The patch antenna as claimed in claim 1, wherein said ground plate (20) further comprises a second vertical lip (76) extending perpendicularly from said second edge of said base plane (22), said second vertical lip (76) being parallel to said first vertical lip (24).

FIG. 1

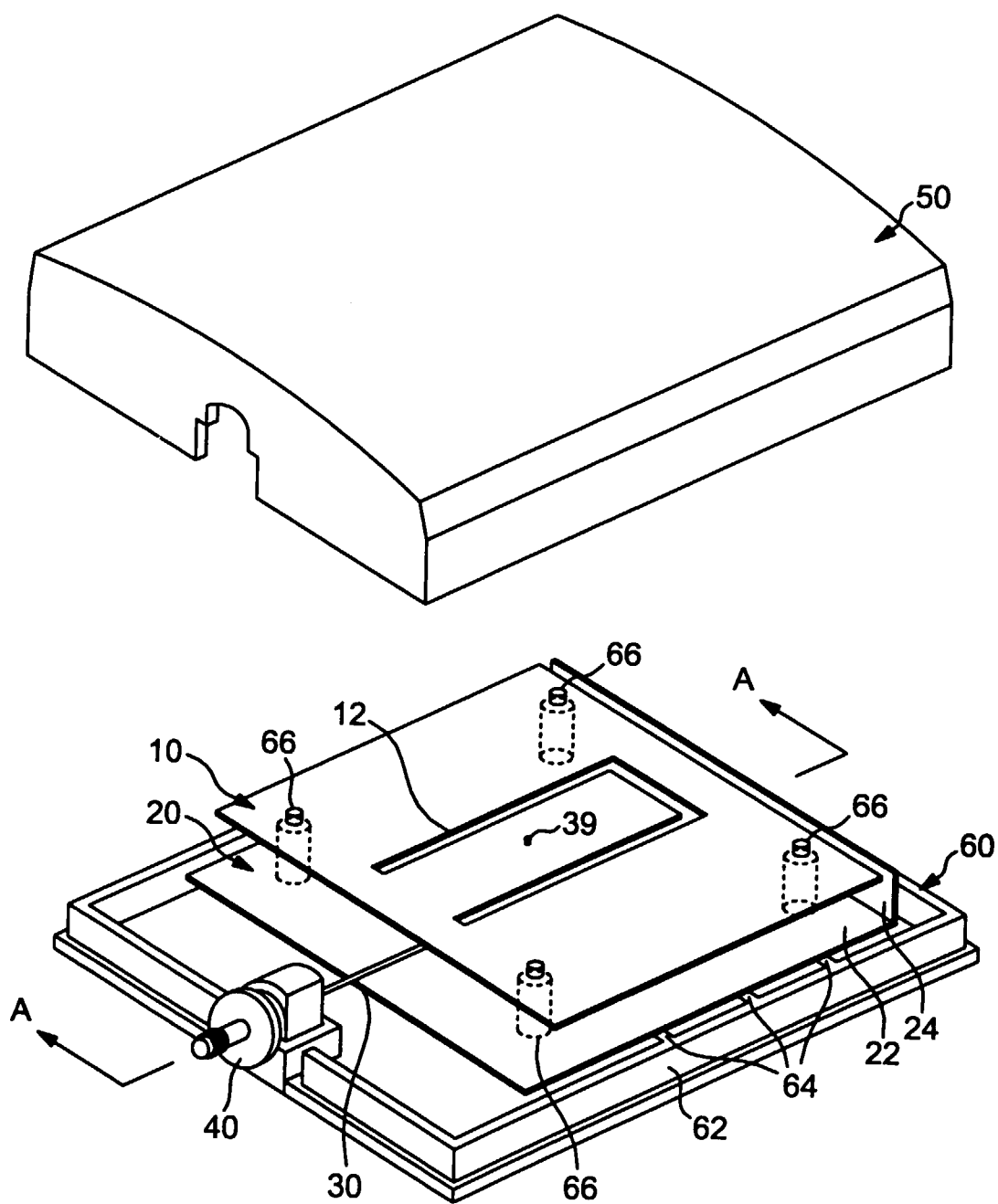


FIG. 2

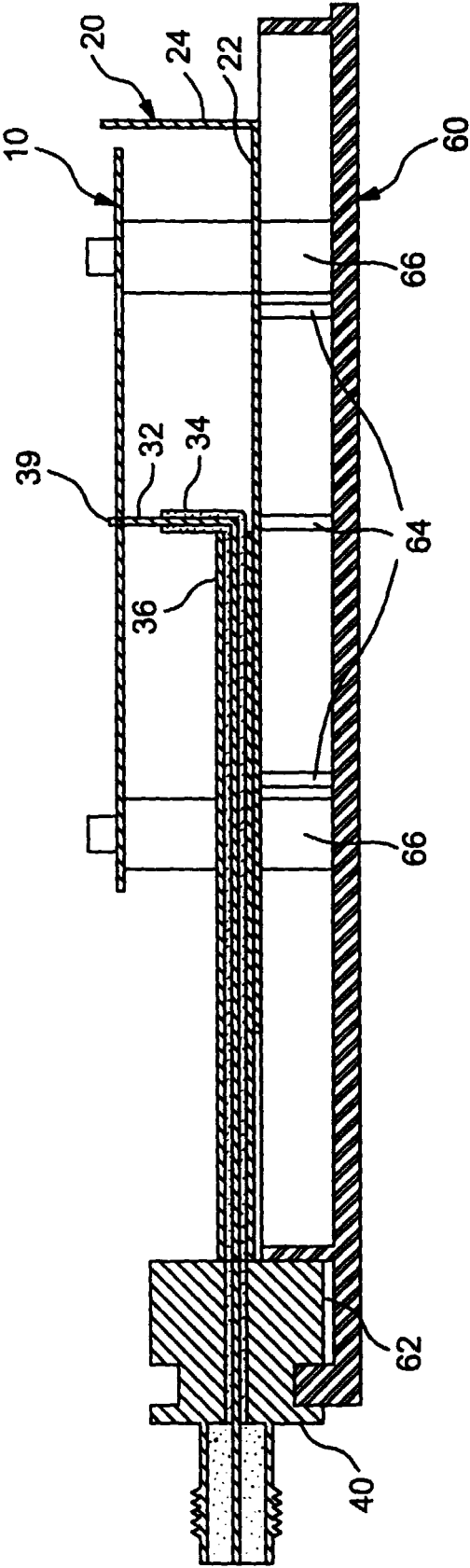


FIG. 3

SWR

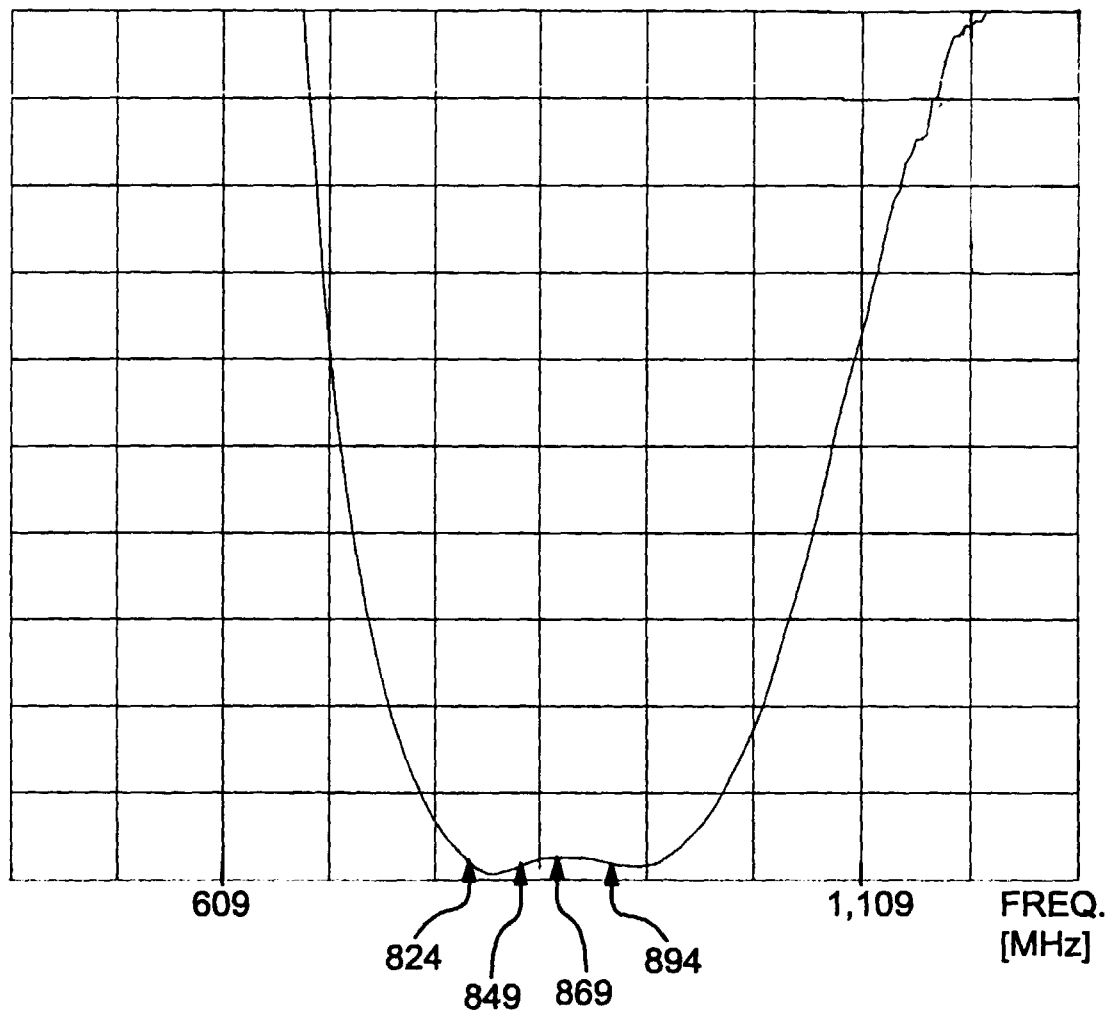


FIG. 4

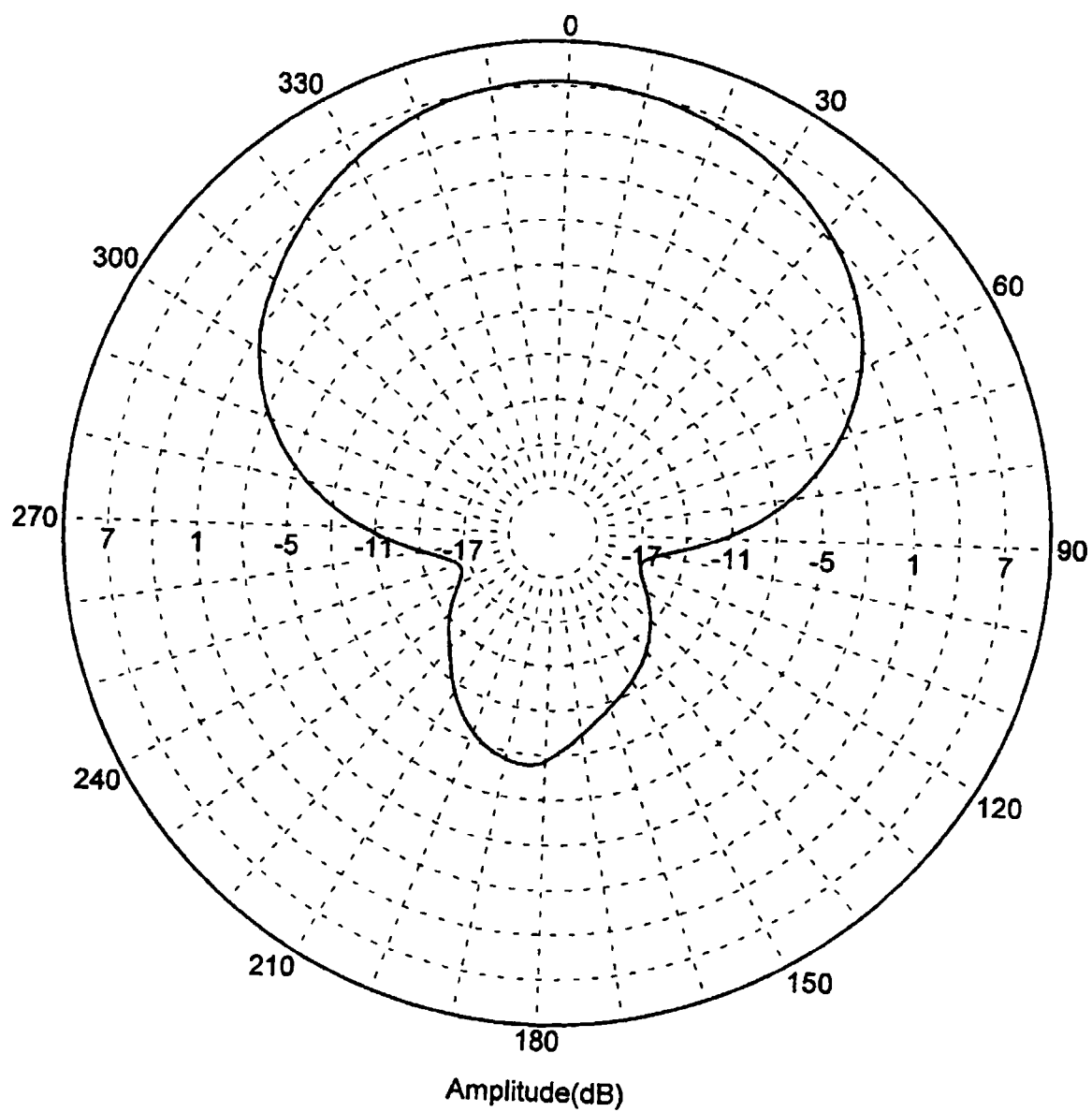




FIG. 5

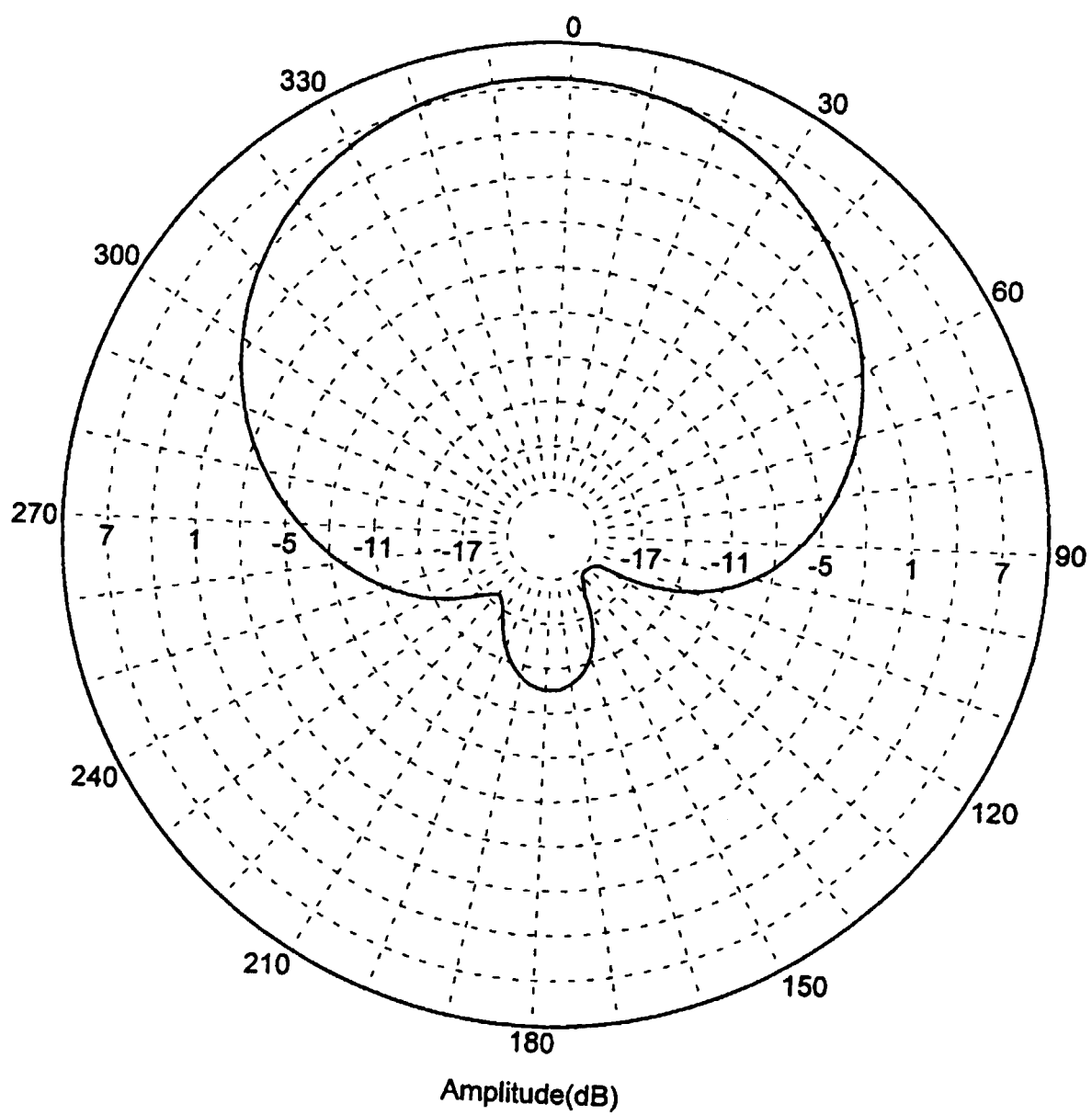


FIG. 6

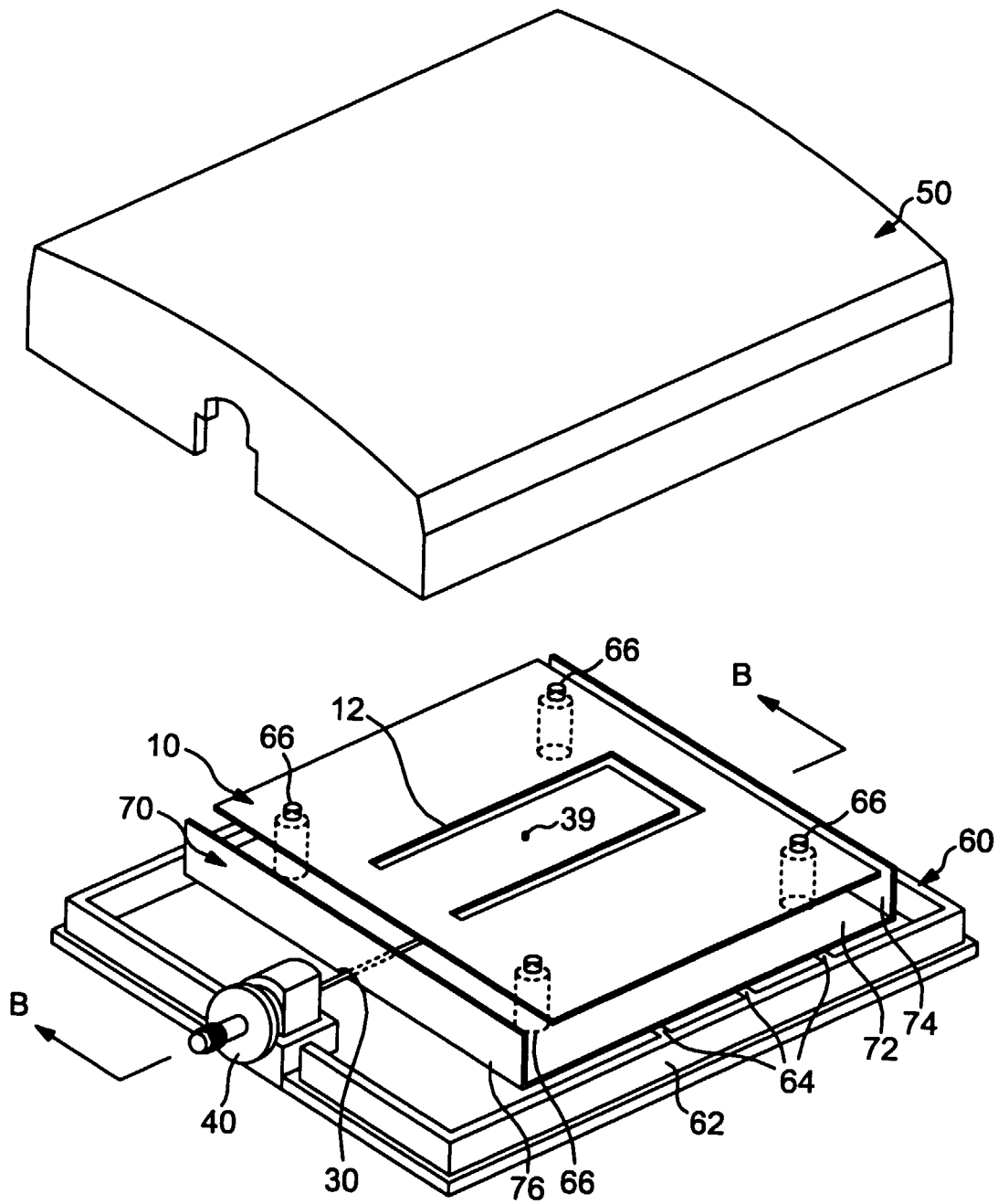
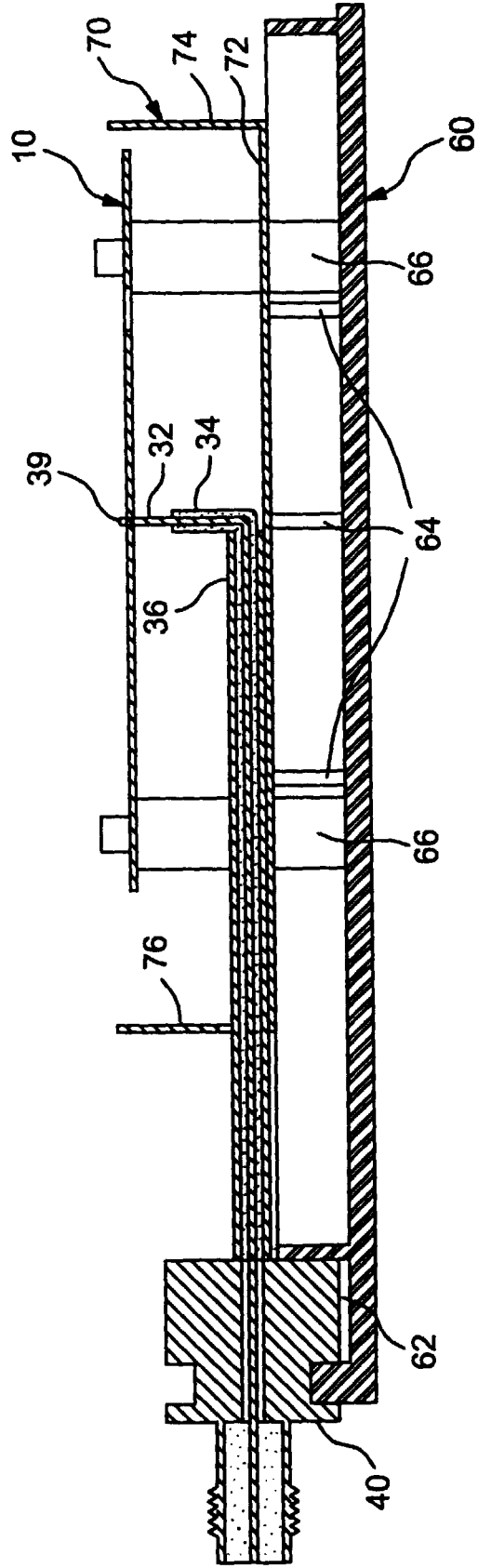


FIG. 7





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# EUROPEAN SEARCH REPORT

Application Number  
EP 99 11 8195

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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P,X	WO 99 43045 A (QUALCOMM INC) 26 August 1999 (1999-08-26) * page 11, line 9 - page 3-9B *	1,2	
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			H01Q
The present search report has been drawn up for all claims			
Place of search <b>MUNICH</b>		Date of completion of the search <b>6 December 1999</b>	Examiner <b>Villafuerte Abrego</b>
<p>CATEGORY OF CITED DOCUMENTS</p> <p>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</p> <p>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</p> <p>&amp; : member of the same patent family, corresponding document</p>			

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 11 8195

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  
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06-12-1999

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