(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 063 721 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
27.12.2000 Bulletin 2000/52

(51) Int Cl.[7]: **H01Q 1/27**

(21) Application number: **00660116.5**

(22) Date of filing: **21.06.2000**

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **24.06.1999 FI 991447**

(71) Applicant: **NOKIA MOBILE PHONES LTD.**
02150 Espoo (FI)

(72) Inventors:
- **Makkonen, Pekka**
  31400 Somero (FI)
- **Tuominen, Mika J.**
  21530 Paimio (FI)

(74) Representative: **Brax, Matti Juhani**
Berggren Oy Ab,
P.O. Box 16
00101 Helsinki (FI)

(54) Planar antenna for a portable radio device

(57) An antenna part (401, 501) for portable radio devices (402, 502) comprises a planar radiator (202) bounded by a certain first outline and attachment means (211, 403, 404) for mechanically attaching the antenna part to a portable radio device. Additionally it comprises a ground plane (204, 414) which is essentially parallel to the planar radiator (202), separated from the planar radiator (202) by a certain essentially constant distance and bounded by a second outline which is essentially the same as the first outline.

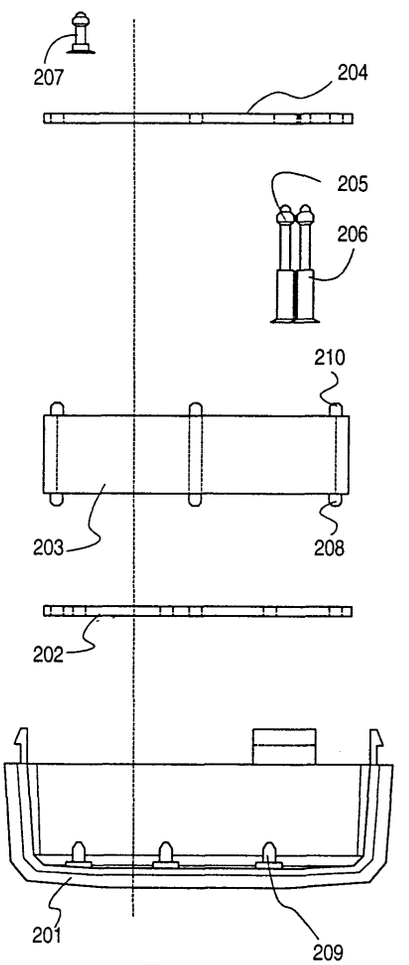

Fig. 2a

EP 1 063 721 A1

Description

[0001] The invention concerns generally the technological field of planar antennas in portable radio devices. Especially the invention concerns a planar antenna construction that has only limited dependencies on the other structures of the radio device. Additionally the invention concerns a portable radio device equipped with such a planar antenna construction.

[0002] Mobile telephones were traditionally fitted with protruding helical antennas and/or fixed or retractable whip antennas. The evolution of smaller and smaller mobile telephones and other portable radio receivers and transceivers like pagers and wirelessly communicating personal digital assistants has promoted the introduction of planar antennas that do not protrude outside the smooth contours of the device. This development will most probably continue in the future.

[0003] One of the known and widely applicable planar antenna solutions used in mobile telephones is the PIFA or Planar Inverted F Antenna. It consists of a planar conductive sheet (that may have a smooth outer contour or comprise various cuts) that acts as a radiator, and a planar conductive ground surface which is essentially parallel to the radiator. The surfaces need not be exactly planar, and they need not be exactly parallel to each other. There are one or a few conductive connections between the radiator and the ground surface, usually implemented as conductive pins or strips that are essentially perpendicular to the direction of the planar surfaces. A feeding pin or a feeding strip coupled to a certain feeding point of the planar radiator serves to couple the antenna to the antenna port of a radio device.

[0004] Fig. 1 illustrates a known PIFA construction and its use in a mobile telephone, which in Fig. 1 is seen in an opened position so that its keypad, display, microphone and loudspeaker which are located on the distant side of the right-hand part are not seen. The functional parts of the mobile telephone 101 have been constructed onto a printed circuit board or PCB 102. The PCB with all the components attached thereto has been enclosed into an outer cover 103 which consists of two halves 103a and 103b and also serves as a support structure. The PCB 102 is attached to the front half 103a of the outer cover. At the top end of the PCB 102 there is an antenna feeding pad 104 and a ground plane 105 which are parts of the conductive structures formed on the planar surface of the PCB. In most mobile telephones and other small radio devices the PCB is of the multilayer type in which case the ground plane 105 could be also located at one of the inner layers.

[0005] At the top end of the inside of the back cover 103b there is a conductive radiator 106 which is made e.g. by glueing a copper sheet or a corresponding flat piece of metal onto the inner surface of the back cover 103b. A feeding pin 107 and a grounding pin 108 protrude from the conductive radiator 106 into a direction which is towards the PCB 102 when the two cover halves 103a and 103b are attached together. The feeding pin 107 and grounding pin 108 are made e.g. by forming a pair of elongated strips at the edge of the copper sheet 106 at the phase when it is cut out of a larger piece of metal, and bending the elongated strips into the appropriate direction. The idea is that when the cover is closed, the conductive radiator 106 and the ground plane 105 come into a parallel configuration and the feeding pin 107 and grounding pin 108 touch the antenna feeding pad 104 and ground plane 105 respectively, so a PIFA antenna is produced. The back cover 103b must be electrically non-conductive at least at its top end where the conductive radiator 106 is located.

[0006] The prior art structure of Fig. 1 has certain drawbacks. The manufacturers of mobile phones usually want to concentrate in their operation on the design of the basic circuitry and functions of the mobile telephones, and buy auxiliary components like antennas from subcontractors. This is not possible with the structure of Fig. 1, unless the subcontractor provides also the back covers or the back covers are circulated back and forth between the telephone manufacturer and the subcontractor. Testing separately the operation of the mobile telephone or the antenna is also problematic, and the operational characteristics of the antenna depend on whether or not the whole back cover of the telephone has been correctly fastened in place.

[0007] It is an object of the present invention to provide a planar antenna structure that would not have the disadvantages of prior art solutions. It is especially an object of the present invention that the antenna structure is applicable to large scale mass production and subcontracting. A further object of the invention is that the antenna structure is reliable in operation.

[0008] The objects of the invention are achieved with a structure where a planar radiator and its associated ground plane are integrated into a structurally independent part which comprises means for attaching it to the main part of a portable radio device.

[0009] The antenna structure according to the invention comprises a planar radiator bounded by a certain first outline and attachment means for mechanically attaching the antenna part to a portable radio device. It is characterized in that it additionally comprises a ground plane which is essentially parallel to the planar radiator, separated from the planar radiator by a certain essentially constant distance and bounded by a second outline which is essentially the same as the first outline.

[0010] The invention applies also to a portable radio device comprising an outer cover having a certain outer appearance, an antenna part having a planar radiator and an inner grounded part. It is characterized in that the antenna part comprises an integral ground plane which is essentially parallel to the planar radiator, separated from the planar radiator by a certain essentially constant distance and coupled to the inner grounded part of the portable radio device.

[0011] According to the invention there is provided a

compact and structurally independent part that houses a planar radiator, an associated ground plane, contact means for arranging the necessary electromagnetic couplings between the antenna structure and the rest of the radio device and the eventual structural parts that provide for mechanical support and appearance. Structural independence means that it is possible to manufacture the antenna part and handle it in the mass production of radio devices essentially without involving the other parts of the radio device. Most advantageously the antenna part also has integrated attaching means for attaching it to a radio device for example by a snap-on joint.

[0012] According to the most advantageous embodiment of the invention the antenna part comprises an outer cover, a radiator element, a support frame and a ground plane in a sandwiched configuration. The contact means are most advantageously contact pins that may be formed of the same material as the radiator element and/or the ground plane. They may also be separate components that are attached to the radiator element and/or the ground plane. A degree of flexibility may be built into the contact pins to provide a spring force that in the completed radio device presses the contact pin(s) against the corresponding contact surface(s) in the rest of the radio device. The grounding connection from the ground plane of the antenna part to that of the radio device does not necessarily need a galvanic contact at all, if there is in the radio device a grounded part that comes in the completed construction near enough to the ground plane of the antenna part so that a capacitive coupling is formed.

[0013] If the outer cover and support frame of the antenna part are made from plastics, an advantageous method of assembling the antenna part is by ultrasonic welding. The plastic parts themselves are most advantageously made by injection moulding.

[0014] The novel features which are considered as characteristic of the invention are set forth in particular in the appended Claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

Fig. 1 illustrates a known planar antenna construction in a mobile telephone,

Figs. 2a and 2b illustrate an antenna part according to the present invention in exploded view,

Figs. 3a and 3b illustrate an antenna part according to the present invention when assembled,

Fig. 4 illustrates the attachment of an antenna part to a mobile telephone and

Fig. 5 illustrates an alternative attachment of an antenna part to a mobile telephone.

[0015] Fig. 2a is an exploded view of an antenna part according to an advantageous embodiment of the present invention. The antenna part consists of an outer cover 201 made of plastics, a planar radiating antenna element 202 made of a metal sheet, a support frame 203 made of plastics, a ground plane 204 made of metal sheet, two long telescopic spring pins 205 and 206 and a short telescopic spring pin 207. The telescopic spring pins are small metallic structures where an upper part may be partly pushed in the vertical direction into a lower part; a spring inside the lower part constantly pushes the upper part towards its topmost position. Fig. 2b is an exploded cutaway diagram of the same antenna part where the cutaway plane corresponds to the vertical dashed line shown in Fig. 2a.

[0016] The antenna part illustrated in Figs. 2a and 2b is assembled by first pressing the radiating antenna element 202 upwards against the lower surface of the support frame 203 so that the lower plastic assembly pins 208 in the latter coincide with the corresponding through holes in the former. The plastic assembly pins 208 are most advantageously clenched on the lower side of the radiating antenna element 202 so that the radiating antenna element 202 is permanently attached to the support frame 203; also in order to make the structure as compact as possible it is necessary not to allow the pins to protrude to a remarkable depth through the radiating antenna element. Thereafter the combined radiating antenna element 202 and support frame 203 is pressed downwards against the outer cover 201 so that the plastic assembly pins 209 in the latter coincide with the corresponding through holes in the radiating antenna element 202. The protruding ends of the plastic assembly pins are again most advantageously clenched on the upper side of the radiating antenna element.

[0017] After that the two long telescopic spring pins 205 and 206 are attached to the upper side of the radiating antenna element 202 by soldering. It should be noted that the invention does not require the use of telescopic spring pins, because any upwards extending conductive elongated elements that are in electrically conductive contact with the radiating antenna element would fulfil the same function. The ground plane 204 is pushed downwards agains the upper surface of the support frame 203 so that the upper plastic assembly pins 210 in the latter coincide with the corresponding through holes in the former. Again the protruding ends of the plastic assembly pins are most advantageously clenched so that a permanently assembled structure is formed and all unnecessarily protruding pin heads are

eliminated. There are holes in the ground plane 204 for the long telescopic spring pins 205 and 206 so that after attaching the ground plane to the support frame the long telescopic spring pins 205 and 206 extend through the ground plane. Because one of the long telescopic spring pins 205 and 206 is meant to be used a feed pin and the other as a grounding pin of the radiating antenna element, the hole for the former is large enough to make sure that the protruding end of the pin does not come into contact with the ground plane, whereas the hole for the latter pin is tight enough so that a conductive connection between the pin and the ground plane is easily obtained e.g. by soldering. Instead of providing a hole for the feed pin the edge of the ground plane may be cut into a shape that defines a notch so that the feed pin does not go through the ground plane but past its edge.

[0018] The assembling of the antenna part is completed by soldering the short telescopic spring pin 207 onto the upper surface of the ground plane 204. Again any elongated conductive element, e.g. a strip of the same piece and material as the ground plane itself, will do. Later we will explain how the antenna part according to the invention may be made even completely without grounding pins.

[0019] The complete antenna part comprises most advantageously some mechanical attachment points through which it is possible to attach it mechanically to a radio device. In the embodiment of Figs. 2a and 2b the edges of the outer cover 201 comprise snap-on tongues 211 that are meant to be snapped into corresponding notches in the body of the radio device. One edge of the outer cover also comprises a lip 212 the task of which is to strengthen the mechanical joint between the antenna part and the radio device and to help to find the correct positioning at the final assembly stages of the radio device. The location of snap-on tongues, lips and other corresponding mechanical attachment means at different points of the antenna part is naturally not limited by the invention in any way. In addition or as an alternative to a snap-on attachment for example screwing, glueing and other attachment means known as such can be used. A snap-on attachment is also possible to make so that the tongues are in the other parts of the radio device, so that the antenna part has only slots.

[0020] In the embodiment of Figs. 2a and 2b the support frame 203 is a complete rectangular structure which corresponds in size and form to the edges of the radiating antenna element 202 and the ground plane 204, and which even comprises a pair of intersecting supporting beams between its inner walls, coinciding with its horizontal symmetry axes. The invention does not require such a complete reinforced rectangular support frame to be used, because more or less any support structure would suffice which keeps the radiating antenna element 202 and the ground plane 204 in essentially planar form and essentially parallel to each other. However, care must be taken to ensure that the antenna structure fulfils the mechanical strength criteria set to portable radio devices in general: the outer cover of the antenna part will most advantageously become a part of the outer cover surface of the radio device, so the antenna part may be the first part to take the impact when the radio device is accidentally dropped or otherwise mistreated and hits a floor or other relatively hard object.

[0021] Figs 3a and 3b show the antenna part of Figs. 2a and 2b in assembled configuration. Although all spring pins are shown in Figs. 3a and 3b to be arranged so that their top ends are on the same level, this is not required by the invention. The height and direction to which each spring pin or other contact means reaches depends on the location of the contact surface in the radio device against which each spring pin or other contact means is meant to be squeezed when the antenna part is attached to a radio device.

[0022] Fig. 4 shows schematically the attachment of an antenna part 401 to a mobile telephone 402. The snap-on tongues 403 and 404 engage the corresponding slots 405 and 406 respectively. The grounding pins 407 and 408 come into contact with the grounding pads 409 and 410 respectively. There is a connection from the grounding pads 409 an 410 to a ground plane on some surface or inner layer of the printed circuit board 416. The feed pin 411 comes into contact with the antenna port pad 412. There is a connection from the antenna port pad 412 to the duplex filter or other functional component in the radio frequency parts of the mobile telephone. The slot 413 defined by the edge of the ground plane 414 prevents contact between the feed pin and the ground plane. The ends 415 of the plastic assembly pins are clenched. Because the antenna part has its own ground plane, the top end of the printed circuit board 416 can be used for components instead of a plain gound plane.

[0023] Fig. 5 shows an alternative embodiment of attaching an antenna part 501 to a mobile telephone 502. The printed circuit board of the mobile telephone 502 does not extend to the top part. Additionally the radio device is very flat at the top part, so when the antenna part is attached, the ground plane 414 comes very near to a conductive coating 504 on the inside of the radio device's front cover. The conductive coating is grounded and acts as an EMI (ElectroMagnetic Interference) shield. The close proximity of the antenna's ground plane and the grounded conductive inside of the front cover makes separate grounding pins unnecessary, because the capacitive coupling therebetween is practically a short circuit on radio frequencies. The feed pin 411 engages with an antenna port pad 412 which is coupled to the duplex filter or other functional part of the mobile telephone through a strip conductor 503. Otherwise the structure is similar to that of Fig. 4.

[0024] Close proximity between the ground plane of the antenna part and a grounded portion of the radio device, and the resulting capacitive coupling and avoidance of separate grounding pins, does not require that the grounded portion of the radio device is an essentially

planar element which is of the equal size as the ground plane. If, for example, in the arrangement of Fig. 5 the top edge of the printed circuit board in the mobile telephone comes relatively close to the antenna ground plane after assembly, a certain grounded portion at or near the top edge of the printed circuit board suffices to establish the capacitive grounding for the antenna.

Claims

1. An antenna part (401, 501) for portable radio devices (402, 502), comprising

   - a planar radiator (202) bounded by a certain first outline and
   - attachment means (211, 403, 404) for mechanically attaching the antenna part to a portable radio device,

   characterized in that it additionally comprises a ground plane (204, 414) which is essentially parallel to the planar radiator (202), separated from the planar radiator (202) by a certain essentially constant distance and bounded by a second outline which is essentially the same as the first outline.

2. An antenna part according to claim 1, **characterized** in that it additionally comprises a support frame (203) attached to both the planar radiator (202) and said ground plane (204, 414).

3. An antenna part according to claim 2, **characterized** in that said support frame (203) is bounded by a third outline which is essentially the same as the first and second outlines.

4. An antenna part according to claim 2, **characterized** in that said support frame (203)

   - comprises a first set of assembly pins (208) and a second set of assembly pins (210),
   - is attached to the planar radiator (202) so that said first set of assembly pins (208) engages with a set of corresponding holes in the planar radiator (202) and
   - is attached to said ground plane (204, 414) so that said second set of assembly pins (210) engages with a set of corresponding holes in said ground plane (204).

5. An antenna part according to claim 4, **characterized** in that the ends of the assembly pins (208, 210) are clenched (415) at the distal sides of the planar radiator (202) and said ground plane (204).

6. An antenna part according to claim 1, **characterized** in that it additionally comprises a feed pin (205, 411) which is galvanically coupled to the planar radiator (202) and extends into a direction which is essentially perpendicular to the planar radiator (202).

7. An antenna part according to claim 6, **characterized** in that said feed pin (205, 411) is a telescopic spring pin.

8. An antenna part according to claim 1, **characterized** in that it additionally comprises at least one grounding pin (206, 207, 407, 408) which is galvanically coupled to the planar radiator (202) and said ground plane (204, 414) and extends into a direction which is essentially perpendicular to the planar radiator (202).

9. An antenna part according to claim 8, **characterized** in that said grounding pin (206, 207, 407, 408) is a telescopic spring pin.

10. An antenna part according to claim 1, **characterized** in that it additionally comprises an outer cover (201) which is attached to the planar radiator (202) and encloses the planar radiator (202) and said ground plane (204).

11. An antenna part according to claim 10, **characterized** in that the attachment means (211, 403, 404) are integral parts of said outer cover (201).

12. A portable radio device (402. 502) comprising

    - an outer cover having a certain outer appearance
    - an antenna part (401, 501) having a planar radiator (202) and
    - an inner grounded part (409, 410, 504),

    characterized in that the antenna part (401, 501) comprises an integral ground plane (204, 414) which is essentially parallel to the planar radiator (202), separated from the planar radiator (202) by a certain essentially constant distance and coupled to the inner grounded part (409, 410, 504)of the portable radio device (402, 502).

13. A portable radio device according to claim 12, **characterized** in that the inner grounded part is a ground plane on a printed circuit board (416).

14. A portable radio device according to claim 12, **characterized** in that the inner grounded part is a grounded conductive coating (504) on the inner surface of the outer cover.

15. A portable radio device according to claim 12, **characterized** in that said integral ground plane (204,

414) of the antenna part (401, 501) is galvanically coupled to the inner grounded part of the portable radio device (402, 502) through a contact pin (206, 207, 407, 408).

16. A portable radio device according to claim 12, **characterized** in that said integral ground plane (204, 414) of the antenna part is capacitively coupled to the inner grounded part of the portable radio device (402, 502).

17. A portable radio device according to claim 12, **characterized** in that the antenna part (401, 501) comprises an outer cover (201) having a certain outer appearance which together with the outer appearance of the portable radio device's outer cover defines a smooth outer surface enclosing the portable radio device (402, 502).

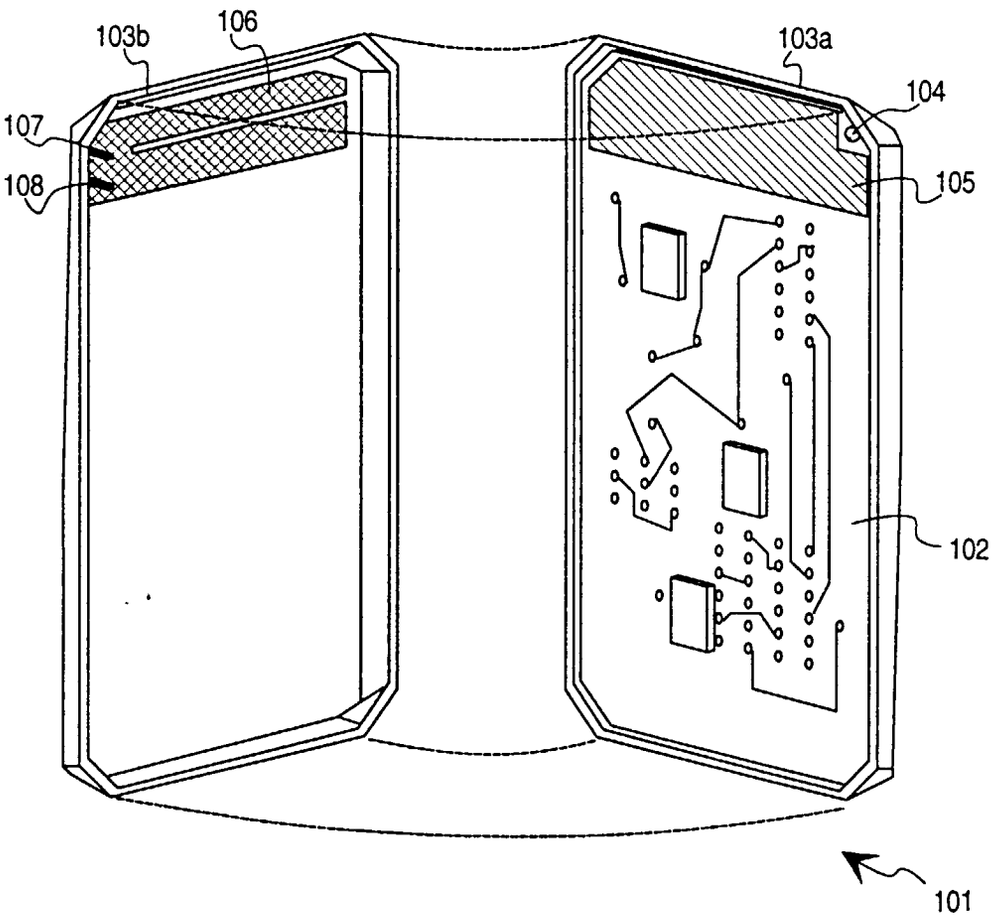

Fig. 1
PRIOR ART

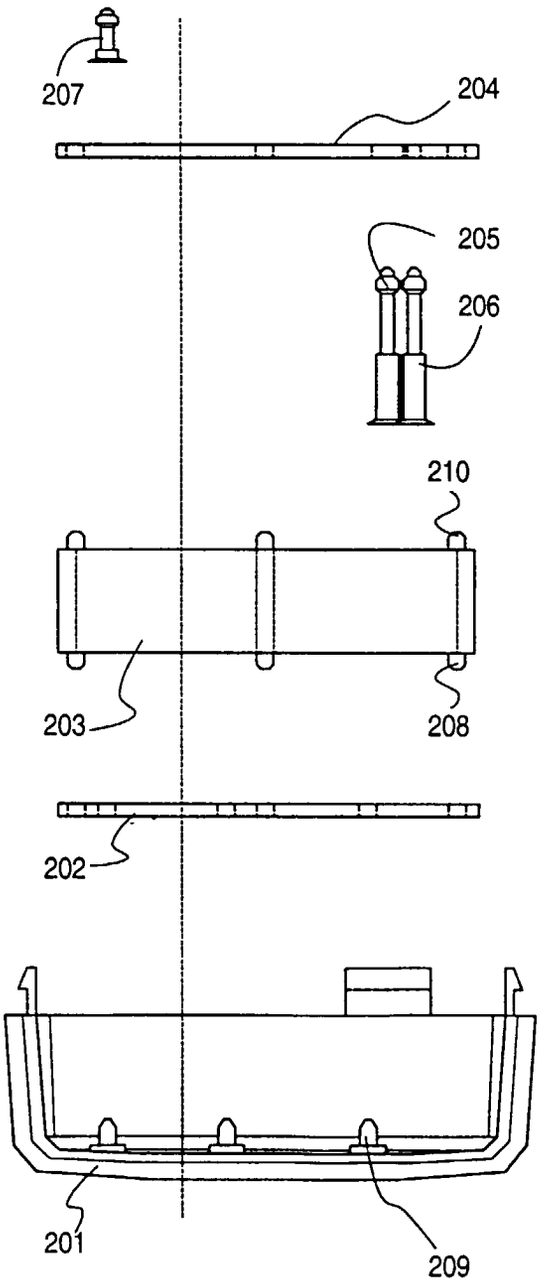

Fig. 2a

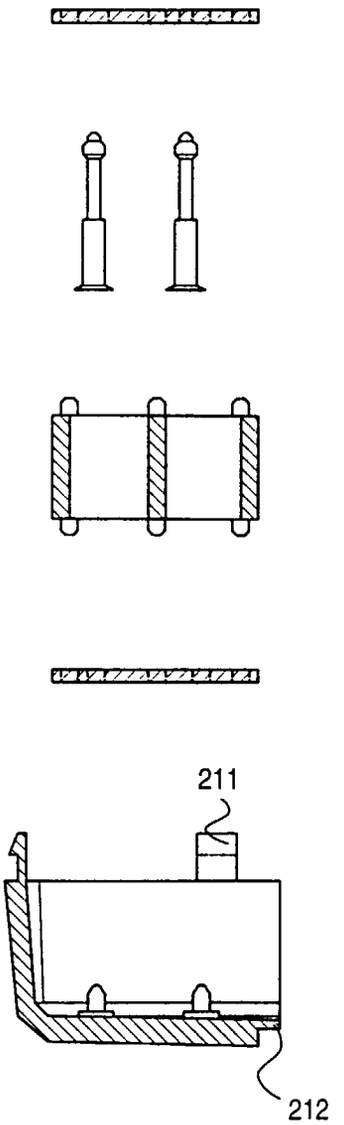

Fig. 2b

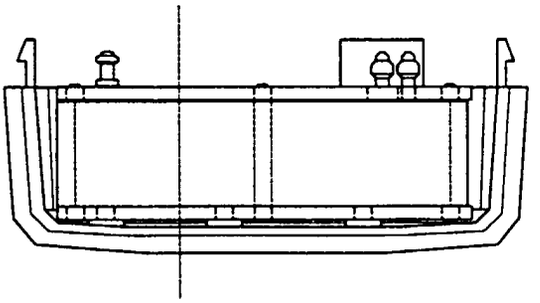

Fig. 3a

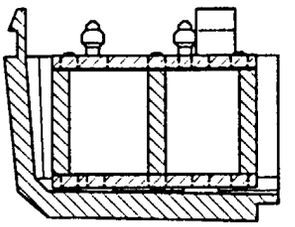

Fig. 3b

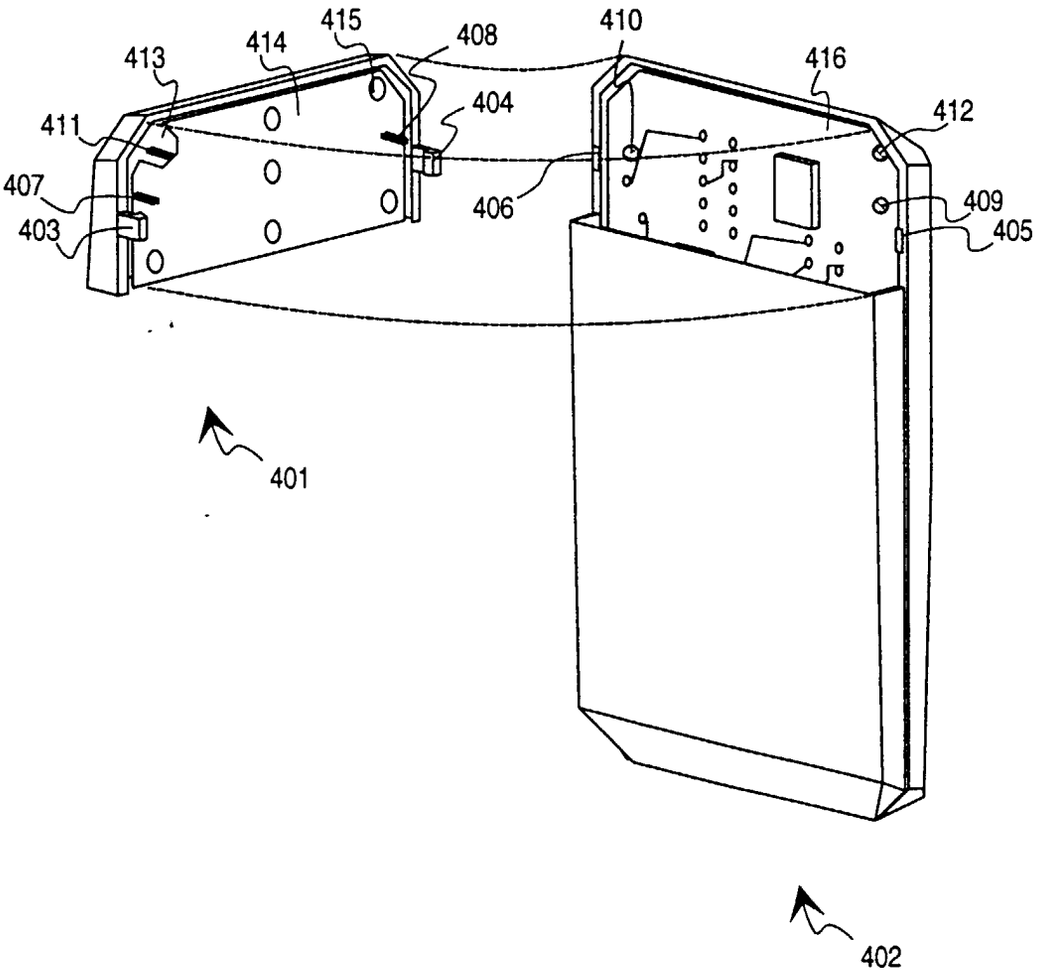

Fig. 4

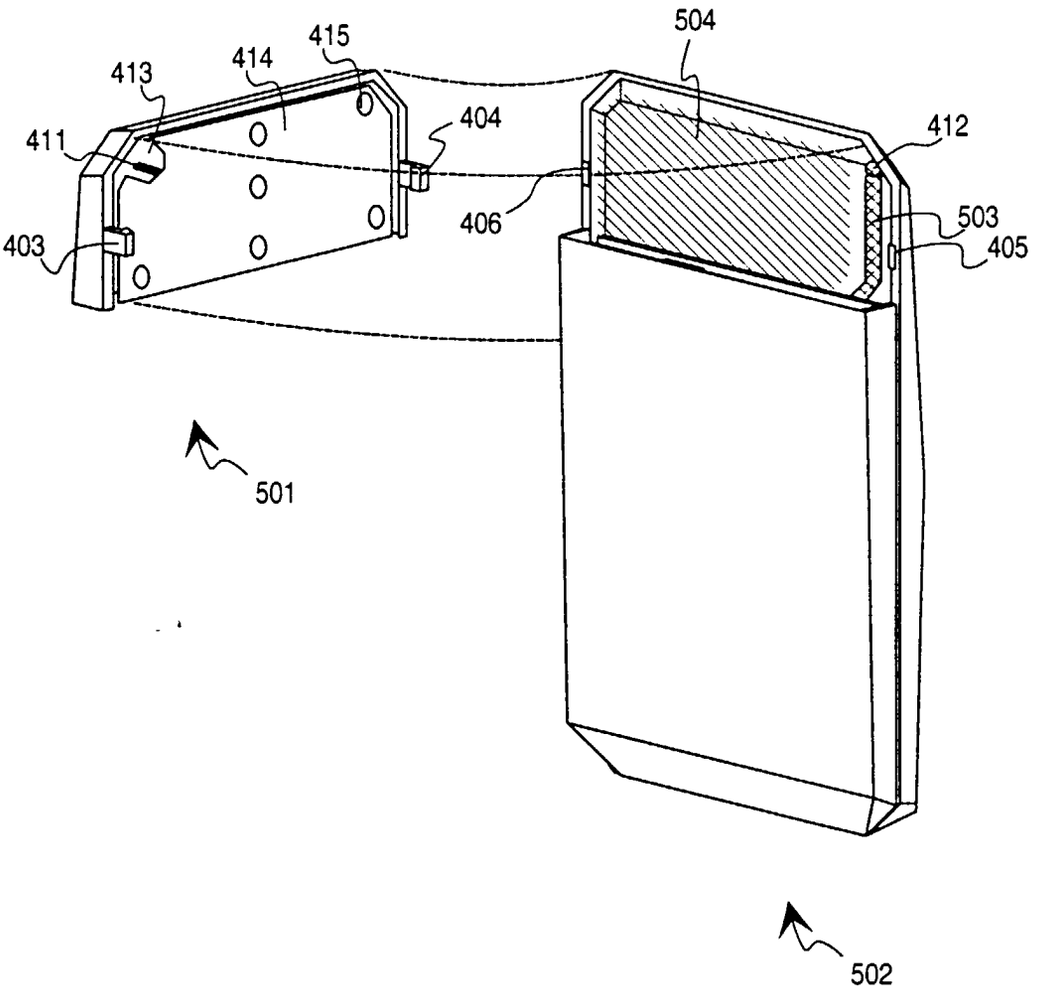

Fig. 5

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 66 0116

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)
P,X	US 5 926 139 A (KORISCH ILYA A) 20 July 1999 (1999-07-20) * the whole document *	1-17	H01Q1/27
X	WO 96 27219 A (UNIV HONG KONG CHINESE) 6 September 1996 (1996-09-06) * page 4, line 2 - page 6, line 24; figures 1-4C *	1-17	
X	WO 99 27607 A (ISOHAETAELAE ANNE ;ANNAMAA PETTERI (FI); LK PRODUCTS OY (FI)) 3 June 1999 (1999-06-03) * page 4, line 12 - page 6, line 3; figures 1-8 *	1-17	
X	EP 0 892 459 A (NOKIA MOBILE PHONES LTD) 20 January 1999 (1999-01-20) * column 4, line 50 - column 4, line 53; figure 2 *	1,12	
A	US 4 694 301 A (WASSUM RAYMOND E) 15 September 1987 (1987-09-15) * column 3, line 3 - column 3, line 18; figures 2,3 *	1-17	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H01Q

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	28 August 2000	Villafuerte Abrego

CATEGORY OF CITED DOCUMENTS

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

T : theory or principle underlying the invention
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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 00 66 0116

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.

28-08-2000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5926139 A	20-07-1999	NONE	
WO 9627219 A	06-09-1996	NONE	
WO 9927607 A	03-06-1999	FI 974316 A AU 1240099 A	26-05-1999 15-06-1999
EP 0892459 A	20-01-1999	FI 972897 A FI 981571 A	09-01-1999 09-01-1999
US 4694301 A	15-09-1987	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82