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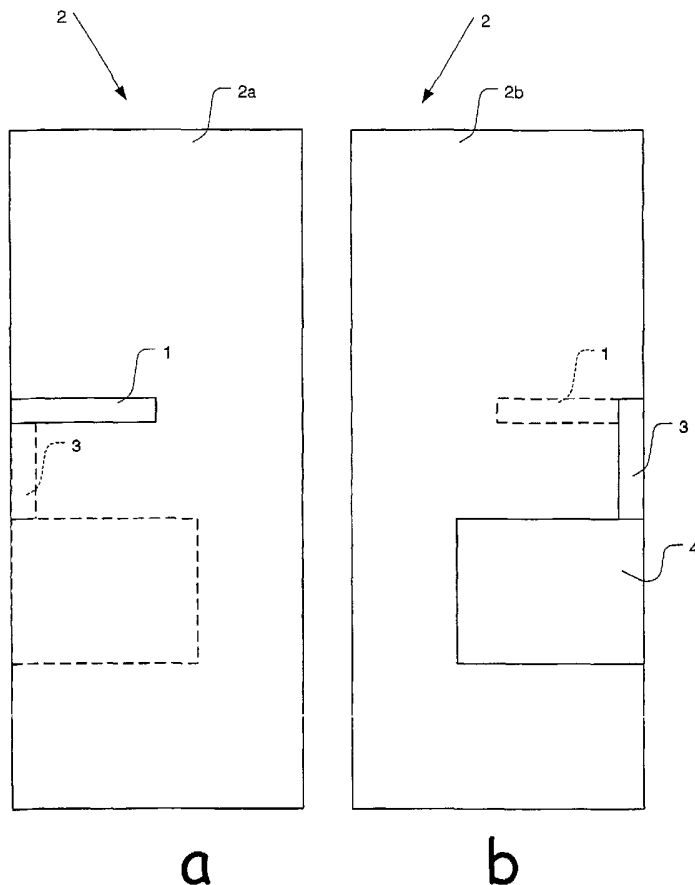
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[Continued on next page]

(54) Title: MONOPOLE SLOT ANTENNA



(57) Abstract: A resonant monopole slot antenna (1) comprising a ground plane, having a radiating slot which is dimensioned such that the slot is equivalent electromagnetically to an odd number of quarter wavelengths at the antenna's operating frequency, wherein the antenna's feed (3) is arranged at the open end of the radiating slot.



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

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Monopole Slot Antenna

The present invention relates to a slot antenna.

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Slot antennas have found wide application in the field of radio communication. Conventional slot antennas comprise halfwave elements. This has put them at a disadvantage, with regard to size, compared with patch or wire antennas, such as the PIFA (planar inverted-F antenna), which can be constructed with
10 quarterwave elements.

Ideally, a wire monopole antenna or the like comprises a quarterwave radiating element perpendicular to an infinite ground plane. This configuration is in practice impossible to achieve. However, in some circumstances, such
15 as a mobile phone, it is impossible even to approximate this configuration well because of other design constraints.

An object of the present invention is to provide a slot antenna that is not at a size disadvantage to PIFA antennas.

20

According to the present invention, there is provided a resonant monopole slot antenna including a radiating slot which is dimensioned such that the slot is equivalent electromagnetically to an odd number of quarter wavelengths at the antenna's operating frequency, wherein the antenna's feed is arranged at
25 the open end of the radiating slot. Feeding the slot at its open end provides a broader usable bandwidth than feeding at a position towards the closed end.

Preferably the antenna's feed is provided at a position at which the maximum E-field occurs.

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The radiating slot may be straight or not straight. If the slot is not straight, it may be, for example, L-shaped or meander.

Preferably, said odd number is 1.

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Preferably, the radiating slot comprises an area of a printed circuit board which is free of conductor. More preferably, said area extends to an edge of the printed circuit board.

10 Preferably, said feed comprises a conductor extending along or parallel to the longitudinal axis or transversely across the radiating slot at its open end.

The feed may comprise a conductor, which could be any transmission line structure, but more preferably, said conductor comprises a signal line of a
15 stripline or microstrip transmission line.

Figure 1 shows the front (figure 1(a)) and back (figure 1(b)) of a PCB carrying a first antenna according to the present invention;

Figure 2 shows the front (figure 2(a)) and back (figure 2(b)) of a PCB
20 carrying a second antenna according to the present invention;

Figure 3 shows the front (figure 3(a)) and back (figure 3(b)) of a PCB carrying a third antenna according to the present invention; and

Figure 4 shows the front (figure 4(a)) and back (figure 4(b)) of a PCB carrying a fourth antenna according to the present invention; and

25 Figure 5 shows metal (figure 5(a)) and plastic (figure 5(b)) radiotelephone casings having a slot antenna according to the present invention.

Preferred embodiments of the present invention will now be described,
30 by way of example only, with reference to the accompanying drawings.

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Referring to Figures 1(a) and 1(b), a slot antenna 1 is formed on a double-sided printed circuit board 2. The slot antenna 1 is formed by removing a strip of copper from a margin of the front side 2a of the printed circuit board 2. The front side 2a (figure 1(a)) of the printed circuit board 2 is otherwise an unbroken ground plane.

The back side 2b (figure 1(b)) of the printed circuit board 2 is devoid of copper save for a microstrip feed 3 to the slot antenna 1 and the tracks of a radio transmitter circuit 4.

The slot antenna 1 is open at the edge of the printed circuit board 2. In the present example, the length of the slot antenna is 12mm and its width is 2mm and the slot antenna resonates at 2451MHz. This is approximately the same resonant frequency that would be expected for a closed slot antenna 24mm long and 2mm wide. Such a closed slot antenna is analogous to a halfwave dipole wire antenna and the present antenna can be viewed as analogous to a quarterwave monopole wire antenna. Consequently, the dimensions of slots with hereinafter be referred to by reference to the analogous wire antenna length.

The microstrip feed 3 to the slot antenna 1 extends along the edge of the printed circuit board 2, perpendicular to the slot antenna 1, figure 1. It is spaced apart from the groundplane, 2a. The microstrip feed 3 terminates behind the slot antenna 1. In this example, the microstrip feed 3 feeds the slot antenna 1 at its high impedance end. Feeding the antenna at the high impedance end in this way provides a good match over a larger bandwidth than can be achieved by feeding the slot at its low impedance end.

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Referring to Figures 2(a) and 2(b), the straight slot of the antenna 1 of Figures 1(a) and 1(b) can be replaced by an L-shaped slot.

Referring to Figures 3(a) and 3(b), the straight slot of the antenna 1 of
5 Figures 1(a) and 1(b) can be replaced by a meandering slot. The feed 3, is shown positioned at the maximum E-field position.

Referring to Figures 4(a) and 4(b), the "quarterwave" slot of the antenna
1 of Figures 1(a) and 1(b) can be extended by units of a "quarterwave",
10 for instance to three "quarterwaves" as shown. In this case the longer length of slot is 36mm. With the feed point at the open end of the slot, the antennas feed impedance will be high for lengths which are odd numbers of "quarterwaves" and low for even numbers of "quarterwaves".

15 Radiotelephone handsets 10 may have largely metal 11 (figure 5(a)) or largely plastic 13 (figure 5(b)) casings. Figure 5(a) shows the outer casing 11 of a handset 10 made from a metal such as steel (conductive material). The side of the handset 10 has a 'T' shape area 12 removed from it; (the shape of the removed area does not have to be a 'T' shape
20 but may for example, be a meander shape). The base of the 'T' shape defines a slot in the metal casing 11 which can be used to provide a slot antenna, subject to arranging the feed section as described previously. In an alternative embodiment, the empty 'T' shape 12 in the side of the handset 10 may be filled in by a plastic (non-conductive) insert.

25 Correspondingly, a side of a radio telephone 10 with a plastic casing 13 (figure 5(b)) may have a 'U' shaped metal insert 14 placed therein to again provide a slot antenna subject to appropriately arranging the feed sections as described previously.

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Although reference to an outer casing is made the antenna could form part of an inner casing which is then covered by an exterior handset casing.

- 5 It will be appreciated that many modifications can be made to the above-described embodiments without departing from the spirit and scope of the claims appended hereto.

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Claims

1. A resonant monopole slot antenna comprising a ground plane, having a radiating slot which is dimensioned such that the slot is equivalent
5 electromagnetically to an odd number of quarter wavelengths at the antenna's operating frequency, wherein the antenna's feed is arranged at the open end of the radiating slot.
2. An antenna according to claim 1, wherein the radiating slot is straight.
10
3. An antenna according to claim 1, wherein the radiating slot is not straight.
4. An antenna according to claim 3, wherein said slot is L-shaped.
15
5. An antenna according to claim 3, wherein said slot meanders.
6. An antenna according to claim 1, wherein said odd number is 1.
- 20 7. An antenna according to claim 1, wherein the radiating slot comprises an area of a printed circuit board which is free of conductor.
8. An antenna according to claim 7, wherein said area extends to an edge of the printed circuit board.
25
9. An antenna according to claim 1, wherein said feed comprises a conductor extending transversely across the radiating slot at its open end.

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10. An antenna according to claim 9, wherein said conductor comprises a signal line of a stripline or microstrip transmission line.
11. An antenna according to claim 1, wherein the feed point is situated so
5 as to coincide with the maximum E field position of the antenna.
12. A radio communications device having a casing; the casing being arranged to be a resonant monopole slot antenna comprising a ground plane, having a radiating slot which is dimensioned such that the slot is
10 equivalent electromagnetically to an odd number of quarter wavelengths at the antenna's operating frequency, wherein the antenna's feed is arranged at the open end of the radiating slot.
13. An antenna according to claim 12, wherein the casing is made from
15 one or more conductive portions.
14. An antenna according to claims 12 or 13, wherein the groundplane is formed from a conductive part of the casing.
- 20 15. An antenna according to claim 12, wherein the slot is filled with a non-conductive portion of the casing.
16. A casing for a radio communications device, wherein the casing is arranged to be a resonant monopole slot antenna comprising a ground
25 plane, having a radiating slot which is dimensioned such that the slot is equivalent electromagnetically to an odd number of quarter wavelengths at the antenna's operating frequency, wherein the antenna's feed is arranged at the open end of the radiating slot.

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17. A resonant monopole slot antenna as hereinbefore described and as with reference to Figures 1 to 5.
- 5 18. A resonant monopole slot antenna as hereinbefore described and as with reference to Figures 1 to 5.
19. A resonant monopole slot antenna as hereinbefore described and as with reference to Figures 1 to 5.

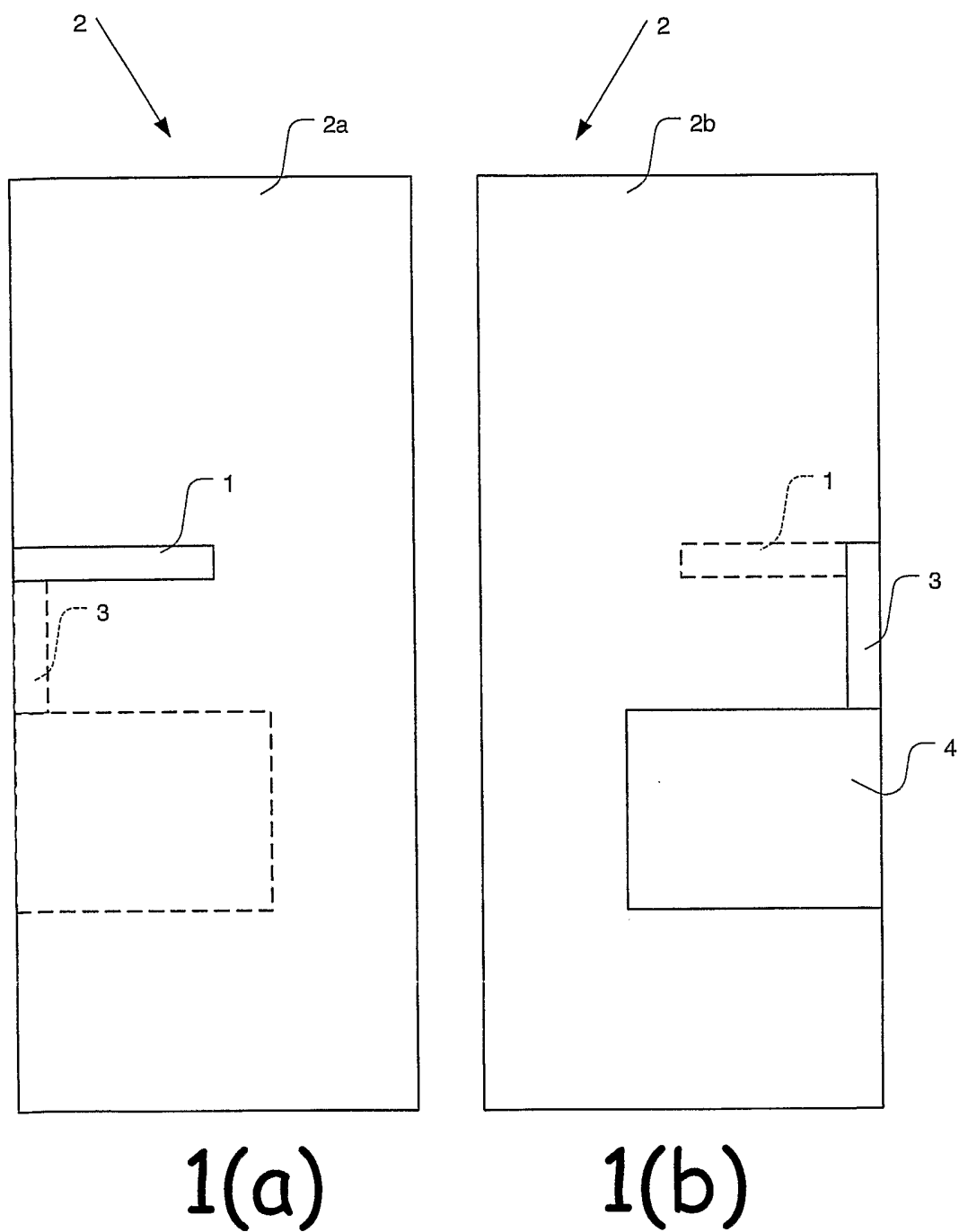


Figure 1

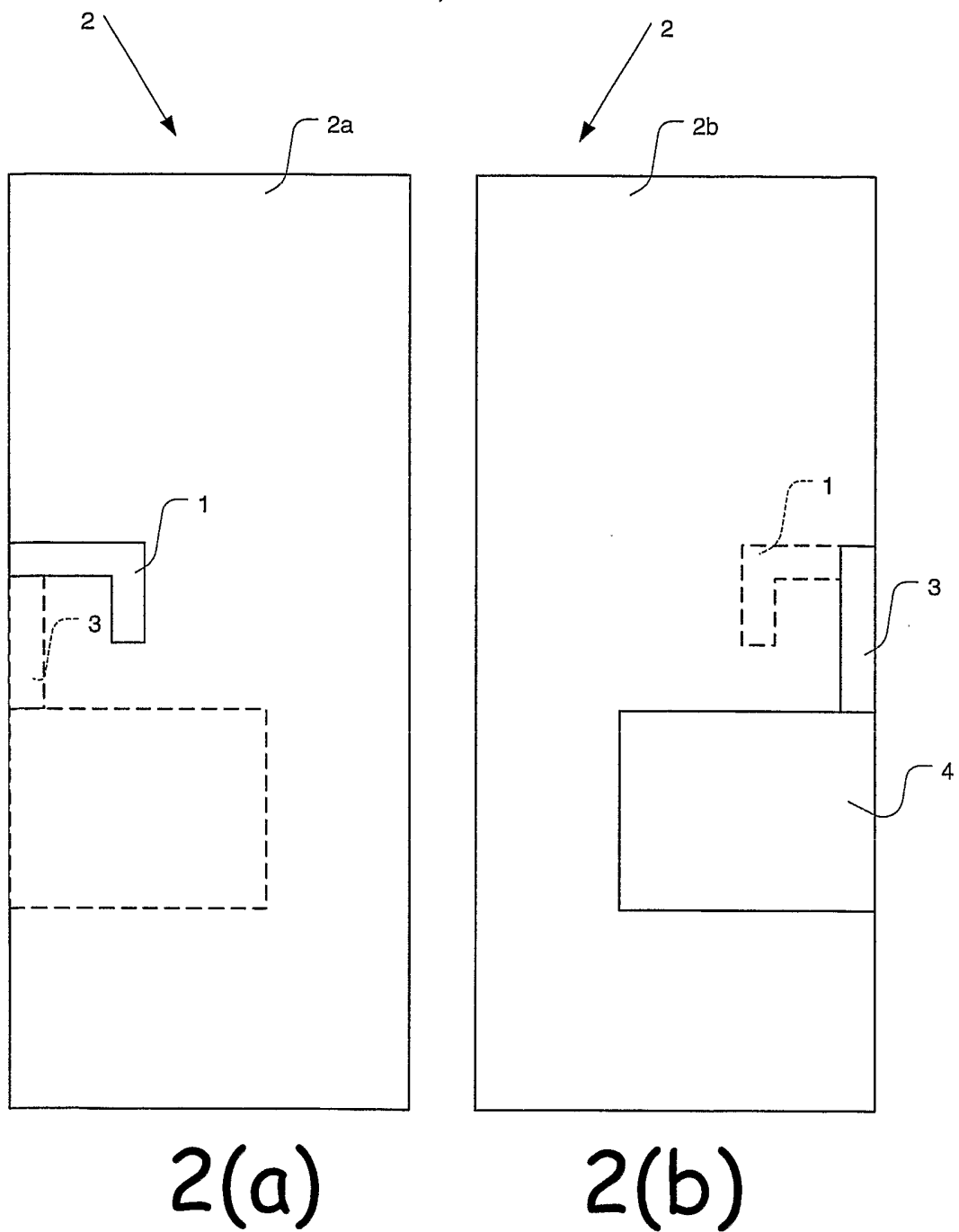


Figure 2

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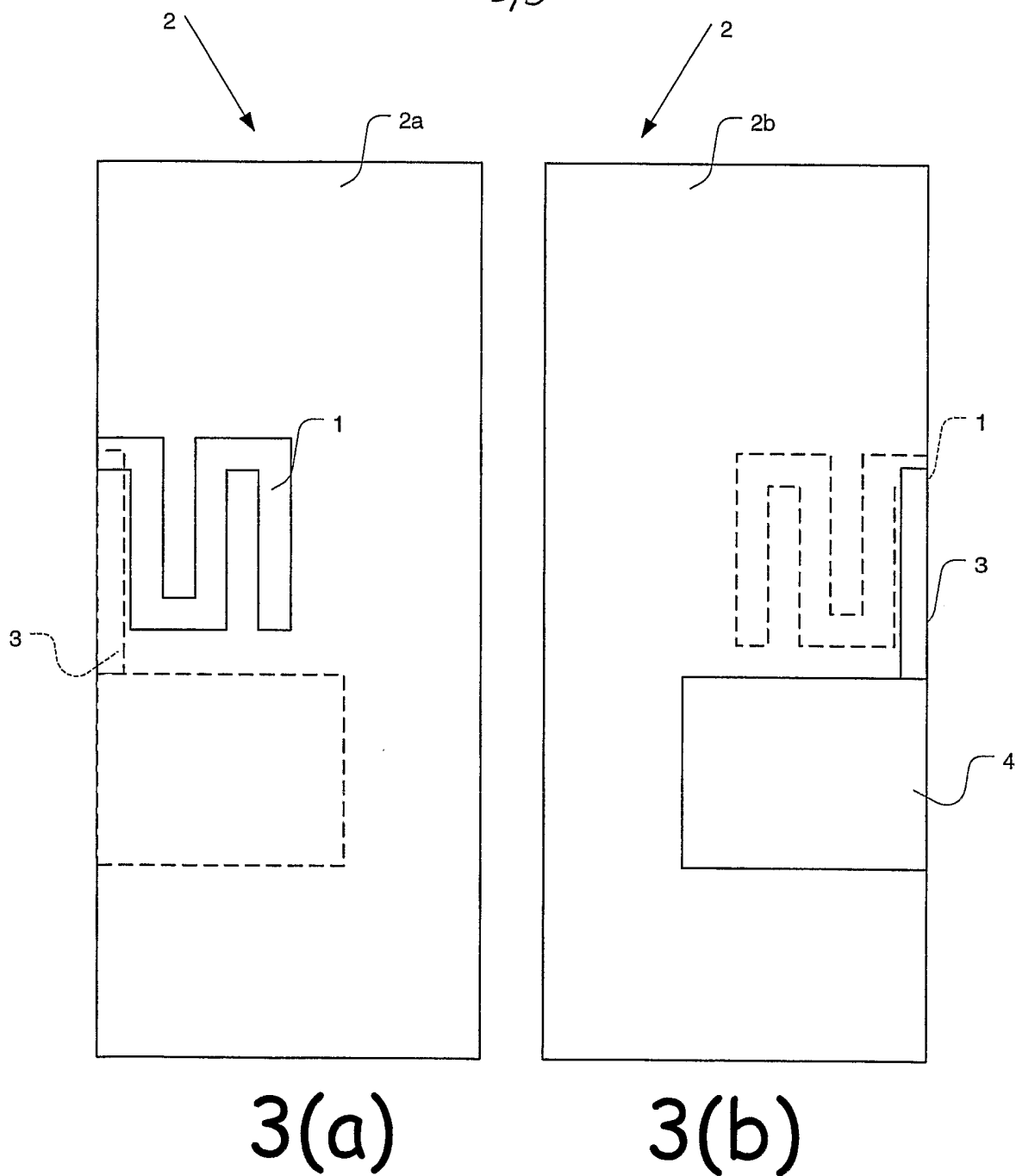
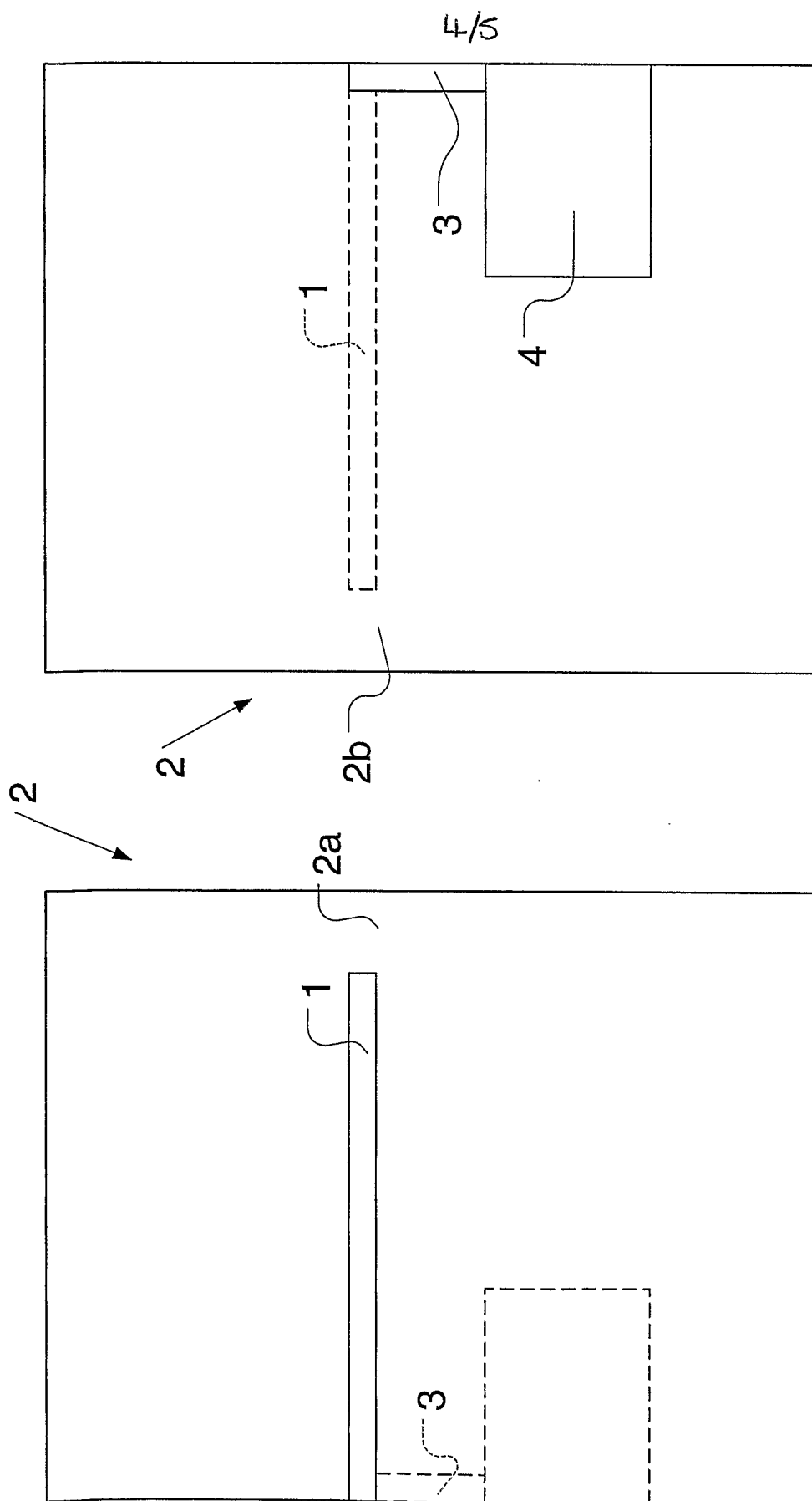


Figure 3



4(b)

Figure 4

4(a)

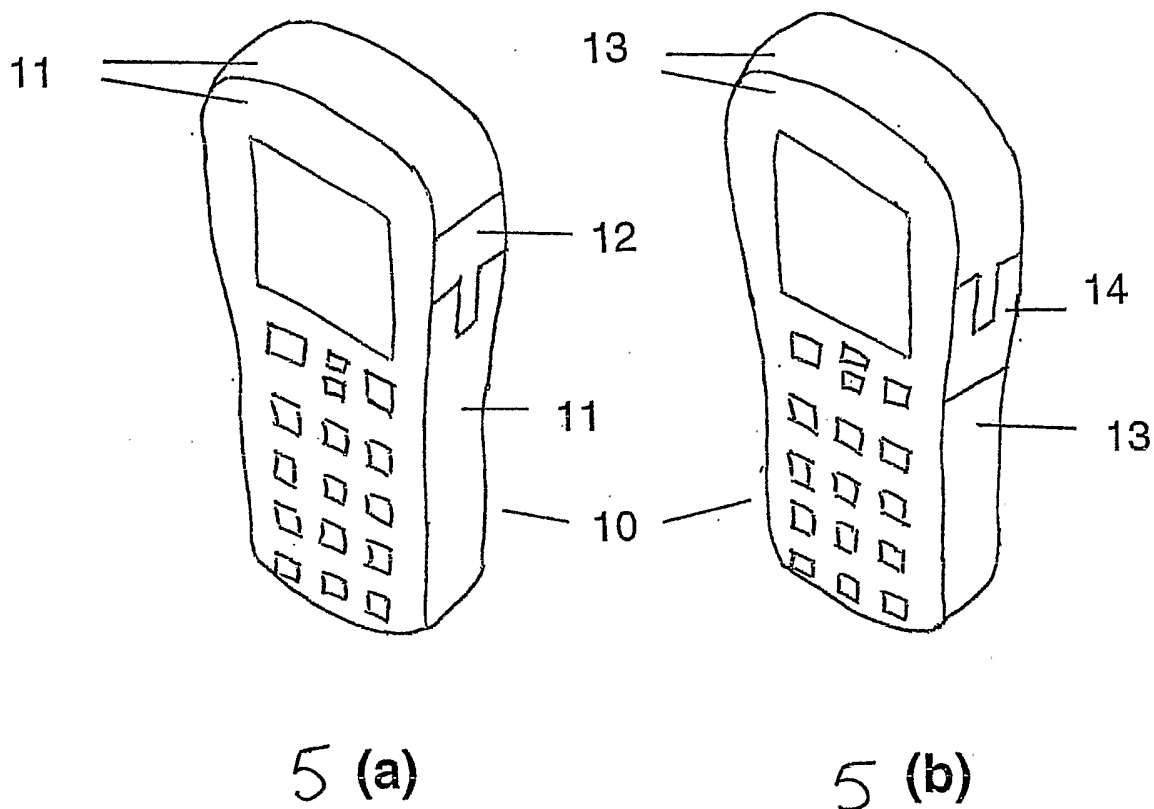


Figure 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 02/05433

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H01Q 1/38, H01Q 13/10, H01Q 1/24
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	PATENT ABSTRACTS OF JAPAN Vol. 2002, No. 12, 12 December 2002 (2002-12-12) abstract & JP 2002 246821 A (TAKAHASHI HITOSHOKANO YOSHINOBU) 30 August 2002 (2002-08-30) figure 2 --	1-2,6-8,11
P,X	US 6424300 B1 (SANFORD, G.G. ET AL), 23 July 2002 (23.07.02), column 11, line 37 - column 13, line 30; column 15, line 19 - line 20, figure 5A --	1-11

Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search Date of mailing of the international search report

27 March 2003

28-03-2003

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 02/05433

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1018779 A2 (LK-PRODUCTS OY), 12 July 2000 (12.07.00), column 5, line 28 - column 6, line 1; column 6, line 23 - line 28; column 7, line 28 - line 33, abstract --	1-8,11-13, 15-16
A	EP 0851530 A2 (LUCENT TECHNOLOGIES INC.), 1 July 1998 (01.07.98), column 3, line 52 - column 4, line 4; column 5, line 34 - line 36; column 6, line 10 - line 17, abstract --	9-16
A	EP 0455493 A2 (MOTOROLA, INC.), 6 November 1991 (06.11.91), column 1, line 18 - line 36, figure 1 --	9-10
A	US 6043786 A (VANNATTA, L.J. ET AL), 28 March 2000 (28.03.00), column 7, line 24 - line 38, figure 10 --	1-16
A	US 4723305 A (PHILLIPS, J.P. ET AL), 2 February 1988 (02.02.88), column 6, line 56 - line 57; column 7, line 17 - line 19, figure 6 -- -----	1-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/12/02

International application No.

PCT/IB 02/05433

Patent document cited in search report			Publication date	Patent family member(s)			Publication date
US	6424300	B1	23/07/02	WO	02063713 A		15/08/02
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				FI	4015 U		16/06/99
				FI	105421 B		00/00/00
				FI	990006 A,V		06/07/00
				US	6252552 B		26/06/01
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				WO	8704307 A		16/07/87

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 02/05433**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: 17-19
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
Claims 17-19 lack technical features and do not comply with Rule 6.2 (a) PCT.

3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest.
 No protest accompanied the payment of additional search fees.